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Screening Study on Feasibility of Standards of Performance for Secondary Aluminum Manufacturing

TRC Environmental Consultants, Inc, Wethersfield, CT

Prepared for

Environmental Protection Agency, Research Triangle Park, NC Emission Standards and Engineering Div

Sep 78

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TRC

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This report contains background information on the secondary aluminum manufacturing industry. The geographical distribution, production, processes, emission sources and rates, state and local air pollution regulations, control techniques and sampling procedures are discussed. This background information has been used in an emission projection model (Model IV) to determine the emission reductions that could be achieved by the application of new source performance standards (NSPS) that require the installation of best available control technology for the period 1977 to 1987.

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SCREENING STUDY ON FEASIBILITY OF STANDARDS OF PERFORMANCE FOR SECONDARY ALUMINUM MANUFACTURING

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THE RESEARCH CORPORATION
OF NEW ENGLAND

ENVIRONMENTAL CONSULTANTS

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1. ABSTRACT

This report contains background information on the secondary aluminum manufacturing industry. The geographical distribution, production, processes, emission sources and rates, state and local air pollution regulations, control techniques and sampling procedures are discussed. This background information has been used in an emission projection model (Model IV) to determine the emission reductions that could be achieved by the application of new source performance standards (NSPS) that require the installation of best available control technology for the period 1977 to 1987.

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3. EXECUTIVE SUMMARY

3.1 INTRODUCTION

Section iii(b) of the Clean Air Act requires the Administrator to set standards of performance for new sources which, in his judgment, cause or contribute significantly to air pollution which may reasonably be anticipated to endanger public health or welfare. Such standards have already been set for a number of industries. The objective of this study was to develop background information on the manufacture of secondary aluminum alloys and to advise on the feasibility and need for standards of performance for this industry.

3.2 INDUSTRY PROFILE

For the purposes of this study, the secondary aluminum industry is defined as that portion of SIC 3341 (Secondary Nonferrous Metals) which recovers, processes, and remelts various grades of aluminum bearing scrap to produce metallic aluminum or an aluminum alloy as a product. This does not include the casting or alloying of remelted billets, ingots, or pigs, nor those operations of the primary aluminum industry which recycle certain categories of scrap.

Based on this definition, there are estimated to be 84 secondary aluminum plants currently operating in the United States. The current annual production of the industry is approximately 454×10^6 kg (0.5×10^6 tons). The production is expected to slowly decrease over the next few years before resuming its previous growth rate. No new construction or modifications were uncovered.

3.3 PROCESSES

There are four distinct phases in the secondary aluminum manufacturing process: collection, sorting and transporting; presmelting preparation; smelting; and pouring. Smelting can consist of six steps: charging, fluxing, alloying, mixing/degassing, demagging (either by chlorination or fluoridation), and skimming.

3.4 EMISSION SOURCES, TYPES AND CONTROLS

The three main sources of air emissions are: the chip dryer (particulate, hydrocarbons, carbon monoxide), the sweat furnace (particulate, hydrocarbons, carbon monoxide), and the reverberatory furnace (particulate, hydrocarbons, carbon monoxide, chlorine and its compounds, and fluorides). The uncontrolled emission rates for particulate were calculated to be 10.5 kg/1000 kg Al for charging the reverberatory furnace, 12 kg/1000 kg AlF_3 for aluminum fluoride demagging, and 500 kg/1000 kg Cl_2 for chlorine demagging. Gaseous fluoride emissions from demagging are 29 kg/1000 kg AlF_3 and chlorine emissions are approximately 200 kg/1000 kg Cl_2.

Controls of these emissions are accomplished using afterburners for the carbonaceous emissions (hydrocarbons and carbon monoxide) and baghouses or scrubbers for particulate matter and reactive gases. The best systems of control have been determined to be an afterburner plus baghouse for the chip dryer and sweat furnace and a coated baghouse for the reverberatory furnace. A wet scrubber with a submerged dome capture system is also effective in controlling reverberatory furnace emissions. Drawbacks to scrubbers include an associated wastewater problem and baghouses have an associated solid waste disposal problem. Coated baghouses and wet scrubbers can be 99.8 percent effective in reducing gaseous fluoride and chlorine emissions.

3.5 STATE AND LOCAL EMISSION REGULATIONS

The state and local emission regulations pertinent to the secondary aluminum industry for the majority of those states containing secondary aluminum manufacturing plants have been examined and tabulated. At present, few states have regulations addressing fluoride emissions and no states examined have regulations for chlorine.

3.6 MODEL IV

Results of the Model IV calculations indicate that the potential reduction of gaseous fluoride and chlorine emissions by application of standards of performance would be 99.8 percent of the projected emissions in 1987. Emissions in 1987 are estimated to be 21,171,000 kg (23,340 tons) for chlorine and 3,094,200 kg (3382 tons) for gaseous fluoride without performance standards and 42,340 kg (47 tons) for chlorine and 5970 kg (7 tons) for gaseous fluoride with performance standards. Particulate emissions would be reduced approximately 70 percent for chip dryers and sweat furnaces and about 40 percent for reverberatory furnaces, assuming state regulations are enforced. Carbonaceous emissions would be reduced 99 percent.

4. SECONDARY ALUMINUM INDUSTRY PROFILE

The following sections will describe the secondary aluminum industry's size and location, capacity and production, and growth trends.

4.1 SIZE AND LOCATION

Based on information obtained from the Department of Commerce, the Aluminum Recycling Association (ARA), and industry/regulatory agency contact, it has been determined that the secondary aluminum industry is currently comprised of approximately 84 plants. The names of the plants, their addresses, and the names of the parent companies, where applicable, are given in Table 4-1. The geographic distribution of the plants is shown in Figure 4-1. Due to the rapidly changing economic nature of the industry, it is recognized that some plants listed may no longer be in operation while others could exist that should be included.

Most of the plants are located near heavily industrialized areas which gives them proximity to a supply of scrap as well as to their customers. There is no need for them to be near plentiful supplies of electrical power and water as in the case of primary aluminum smelters. Most of these plants are located in the Midwest, in or near the Chicago and Cleveland metropolitan areas, and in the West in the Los Angeles area. The East Coast has plants located near the New York City-Philadelphia area. There are none in the Rocky Mountain states.

Plants in this industry vary in size from small, simple operations located on sites as small as one acre and employing as few as six people, to fairly complex plants employing several hundred employees at a given site and occupying up to 50 acres.[1] The plant ages vary considerably with some of the facilities 40 to 50 years old.

TABLE 4-1

The Secondary Aluminum Industry

State	Company/Address	Parent Company/Headquarters
AL	Berman Bros. Iron & Metal Co., Inc. 2501 First Avenue Birmingham, AL 35203	-
AL	Bullock (W.J.), Inc. P.O. Box 539 Fairfield, AL 35064	-
AL	Commercial Metals Co. Munford, AL 36268	Commercial Metals Co. P.O. Box 1046 3000 Diamond Parkway Dallas, TX 75221
AL	Culp Smelting & Refining Co. Route #1 Steele, AL 35987	Culp Iron & Metal Co.
AL	Kimberling (M.) & Sons, Inc. P.O. Box 1108 2020 Vanderbilt Road Birmingham, AL 35201	-
AL	U.S. Reduction Co. Russellville, AL 35653	U.S. Reduction Co. American Can Co. P.O. Box 30 4610 Melville Avenue East Chicago, IN 46312
AR	Vulcan Materials Co. Hot Springs, AR 71901	Vulcan Materials Co. Aluminum Magnesium Division One Huron Street Sandusky, OH 44870
CA	Aetna Metals Co. 13329 East Ector Street City of Industry, CA 91746	-
CA	Chersky (Jon) & Sons 3500 Emery Street East Los Angeles, CA 90023	-
CA	General Metals Refining Co. 14700 South Avelon Boulevard Gardena, CA 90248	-

State	Company/Address	Parent Company/Headquarters
CA	Globe Metals Co. 1820 Tenth Street Oakland, CA 94607	-
CA	Goldberg Metal Refining Corp. 14700 South Avalon Boulevard Gardena, CA 90247	-
CA	Kirk (Morris P.) & Con 2700 South Indiana Street Los Angeles, CA 90023	NL Industries
CA	Liston Brick Company 20401 Temescal Canyon Road Corona, CA 91720	-
CA	McGowan Co., Inc. 1205 South Boyle Avenue Los Angeles, CA 90023	-
CA	Progressive Metals Co. P.O. Box 371 16914 South Broadway Gardena, CA 90247	
CA	U.S. Reduction Co. Ontario, CA 91761	U.S. Reduction Co. American Can Co. P.O. Box 30 4610 Melville Avenue East Chicago, IN 46312
CA	Vista Metals Corp. 13425 Whittram Street Fontana, CA 92335	-
CA	Vulcan Materials Co. Corona, CA 91720	Vulcan Materials Co. Aluminum Magnesium Division One Huron Street Sandusky, OH 44870
CT	Batchelder (Charles) Co., Inc. Swamp Road Botsford, CT 06404	-
CT	Infeld Metals Co. 40 Falls Avenue Waterbury, CT 06708	-
DE	North American Smelting Co. Marine Terminal Wilmington, DE 19899	-

State	Company/Address	Parent Company/Headquarters
GA	Keystone Resources Aluminum Division P.O. Box 687 Greensboro, GA 30642	-
IL	Allied Metal Co. 2059 South Canal Street Chicago, IL 60616	-
IL	Apex International Alloys, Inc. Chicago, IL	Alumax, Inc. Suite 215 2340 Des Plaines Avenue Des Plaines, IL 60018
IL	Behr (Joseph) & Sons, Inc. 1100 Seminary Street Rockford, IL 61108	-
IL	Carroll (Donadl) Metals, Inc. 201 North Division Street Bensenville, IL 60106	-
IL	Hall Aluminum Co. P.O. Box 223 17th & State Street Chicago Heights, IL 60411	-
IL	Harco Aluminum, Inc. 4528 West Division Street Chicago, IL 60651	-
IL	Intercontinental Alloys Lockport, IL 60441	Intercontinental Alloys P.O. Box 920 North Broadway Joliet, IL 60434
IL	Lavin (R.) & Sons, Inc. 3426 Kedzie Avenue Chicago, IL 60623	-
IL	Lissner Corporation 1000 North Branch Street Chicago, IL 60622	-
IL	U.S. Reduction Co. Alton, IL 62002	U.S. Reduction Co. American Can Co. P.O. Box 30 4610 Melville Avenue East Chicago, IN 46312

State	Company/Address	Parent Company/Headquarters
IL	Wilmar Processing, Inc. Aurora, IL	Tower Metals & Ore Corp. 332 South Michigan Avenue Chicago, IL 60604
IN	Apex International Alloys, Inc. Bicknell, IN 47512	Alumax, Inc. Suite 215 2340 Des Plaines Avenue Des Plaines, IL 60018
IN	Barmet Industries, Inc. Rockport, IN 47635	Barmet Industries, Inc. 735 W. Waterloo Road Akron, OH 44314
IN	South Bend Smelting & Refining Co. 1610 Circle Avenue South Bend, IN 46621	-
IN	U.S. Reduction Co. East Chicago, IN 46312	U.S. Reduction Co. American Can Co. P.O. Box 30 4610 Melville Avenue East Chicago, IN 46312
IN	Wabash Alloys, A&C Div. Wabash, IN 46992	Ogden Metals Corp. 20521 Chagrin Street Cleveland, OH 44122
KS	S-G Metals Industries, Inc. Riverview at Second Street Kansas City, KS	-
KS	Tower Metals & Ore Corp. Fort Scott, KS 66701	Tower Metals & Ore Corp. 332 South Michigan Avenue Chicago, IL 60604
KS	Tower Metals & Ore Corp. Oswego, KS 67356	Tower Metals & Ore Corp. 332 South Michigan Avenue Chicago, IL 60604
KY	Ohio Valley Aluminum Co., Inc. P.O. Box 69 Shelbyville, KY 40065	-
LA	Alexandria Metallurgical Corp. P.O. Box 109 Alexandria, LA 71301	-
MD	Eastern Metals 4201 East Monument Street Baltimore, MD 21205	-

State	Company/Address	Parent Company/Headquarters
MD	Tomke Aluminum Division Baltimore, MD.	United Iron & Metal Co., Inc. 4201 East Monument Street Baltimore, MD 21205
MI	Grand Rapids Smelting, Inc. 1370 Belfield, S.W. Grand Rapids, MI 49509	-
MI	Michigan Standard Alloys, Inc. Milton at Mendal Streets Benton Harbor, MI 49022	-
MO	Aluminum Service Corp. Hazelwood, MO	Diversified Industries, Inc. 7701 Forsyth Street St. Louis, MO 63105
MO	Holtzman Metal Co. 510 Withers Avenue St. Louis, MO 63147	-
NE	Northwestern Metal Co. P.O. Box 3456, Station C North 27th & Industrial Park Lincoln, NE 68503	-
NY	Elkins (J.R.), Inc. 518 Gardner Avenue Brooklyn, NY 11222	-
NY	Rochester Smelting & Refining Co., Inc. P.O. Box 547 26 Scherer Street Rochester, NY 14602	-
NY	Roth Brothers Smelting Corp. P.O. Box 158 Thompson Road East Syracuse, NY 13200	-
NC	Lee Aluminum Processing Corp. Highways 15-501 North Sanford, NC 27330	-
OH	Aluminum Billets, Inc. Niles, OH 44446	EASCO Corp. 2100 Arlington Federal Building Baltimore, MD 21201
OH	Aluminum Smelting & Refining Co. 5463 Dunham Road, Maple Heights Cleveland, OH 44137	-
OH	Apex International Alloys, Inc. Cleveland, OH	Alumax, Inc. Suite 215 2340 Des Plaines Avenue Des Plaines, IL 60018

State	Company/Address	Parent Company/Headquarters
OH	Barmet Industries, Inc. Akron, OH	Barmet Industries, Inc. 735 West Waterloo Road Akron, OH 44314
OH	Barmet Industries, Inc. Uhrichsville, OH	Barmet Industries, Inc. 735 West Waterloo Road Akron, OH 44314
OH	Bradley Metals Co. 4275 Bradley Road, S.W. Cleveland, OH 44109	-
OH	Cleveland Electro Metals Co. Cleveland, OH	Keystone Metal Co. 2391 West 48th Street Cleveland, OH 44113
OH	Garfield Co. 55 First Avenue Berea, OH 44017	-
OH	Monarch Aluminum Mfg. Co. 9205 Detroit Avenue Cleveland, OH 44102	-
OH	Ogden Metals Inc. Brook Park, OH 44142	Ogden Metals Corp. 20521 Chagrin Street Cleveland, OH 44122
OH	Rock Creek Aluminum Co. (The) 3305 Mill Street Rock Creek, OH 44084	-
OH	U.S. Reduction Co. Toledo, OH	U.S. Reduction Co. American Can Co. P.O. Box 30 4610 Melville Avenue East Chicago, IN 46312
OH	Vulcan Materials Co. Sandusky, OH 44870	Vulcan Materials Co. Aluminum Magnesium Division One Huron Street Sandusky, OH 44870
OH	Wabash Alloys, A&C Division Cleveland, OH	Ogden Metals Corp. 20521 Chagrin Street Cleveland, OH 44122
OK	Apex International Alloys, Inc. Checotah, OK 74426	Alumax, Inc. Suite 215 2340 Des Plaines Avenue Des Plaines, IL 60018

State	Company/Address	Parent Company/Headquarters
PA	Alan Barr Aluminum Co., Inc. 118 East Front Street Palmyra, PA 17078	-
PA	Gettysburg Foundry Specialties Co. P.O. Box 421 Gettysburg, PA 17325	-
PA	Jobbins (William F.), Inc. U.S. Aluminum Marietta, PA	U.S. Reduction Co. American Can Company P.O. Box 30 4610 Melville Avenue East Chicago, IN 46312
PA	Sall (The George) Metals Co. Philadelphia, PA	Diversified Industries, Inc. 7701 Forsyth Street St. Louis, MO 63105
SC	Batchelder-Blasius, Inc. Spartanburg, SC 29301	Batchelder-Blasius, Inc. P.O. Box 5503 Spartanburg, SC 29301
SC	Batchelder-Blasius, Inc. Wellford, SC 29385	Batchelder-Blasius, Inc. P.O. Box 5503 Spartanburg, SC 29301
TN	Excel Smelting Corp. P.O. Box 7222 1300 North Seventh Street Memphis, TN 38107	-
TN	Rayclan Corp. American Recycling, Inc. P.O. Box 525 Mount Pleasant, TN 38407	-
TX	Abasco, Inc. Addison, TX 75001	Abasco, Inc. P.O. Box 13367 Dallas, TX
TX	Gulf Reduction Corp. (The) 6030 Esperson Street Houston, TX 77011	-
VA	Viener (Hyman) & Son P.O. Box 573 5200 Hatcher Street Richmond, VA 23231	-

State	Company/Address	Parent Company/Headquarters
WA	HI-Duty Alloys Corp. 7201 East Marginal Way South Seattle, WA 98108	-
WA	Materials Reclamation Co., Inc. 6760 West Marginal Way, S.W. Seattle, WA 98106	-
WI	Vulcan Materials Co. Oak Creek, WI 53154	Vulcan Materials Co. Aluminum & Magnesium Div. One Huron Street Sandusky, OH 44870

4.2 PRODUCTION AND CAPACITY

The production of secondary aluminum alloys by smelters, broken down by type of alloy, is presented in Table 4-2 for those years where comparible data were obtained. The yearly totals are plotted in Figure 4-2. The values presented are for the industry as a whole. Production can range from 90,700 kg/mo (100 tons/mo) up to 454,000 kg/mo (5000 tons/mo).[2] The production at each plant can also vary significantly. Unlike primary aluminum plants, secondary smelters do not operate around the clock for seven days. They may operate continuously five days a week and thus can step up production by operating extra shifts. There is not necessarily a relationship between either employment and site area or production and site area of a plant. This is noted from the fact that several very large producers in metropolitan areas have small plant sites due to the high cost of land. Production figures for individual plants and/or processes are held to be proprietary by the industry and are thus not included in this report.

The output capacity of the secondary aluminum industry can be approximated by assuming a value for the ratio of actual production to theoretical capacity. According to industrial contacts, plants typically run at around 60 per cent of capacity. The difference is due to time lost in cleaning out furnaces, replacing furnaces, general clean-up, weighing, not operating 24 hours per day and seven days per week, etc. Therefore, the theoretical capacity of the industry would be 66.7 per cent greater than the actual production. However, this is a fictitious number since the industry is realistically incapable of operation at 100 per cent capacity.

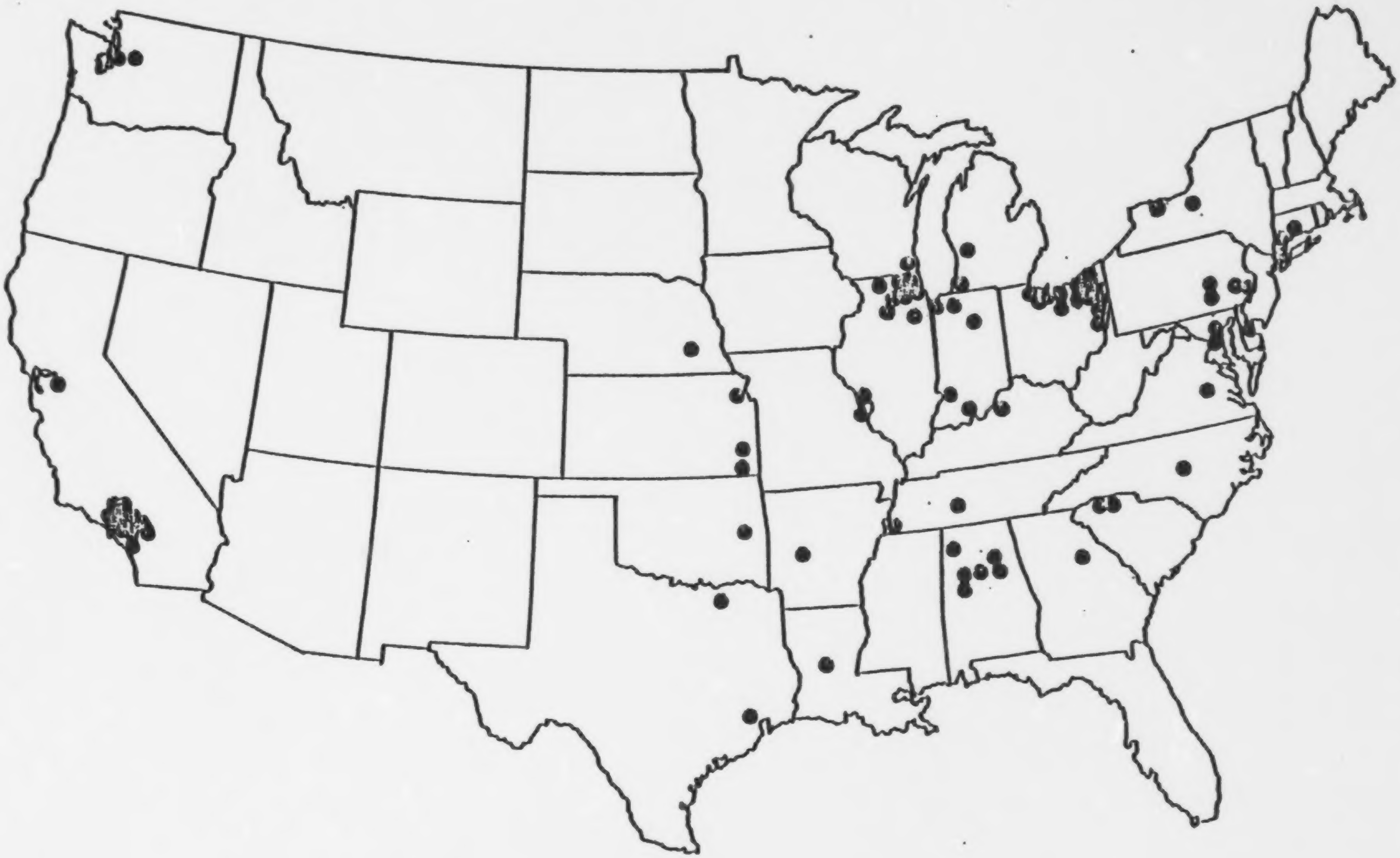

Figure 4-1. Geographic distribution of secondary aluminum smelters in the United States.

Table 4-2. PRODUCTION OF ALUMINUM ALLOYS BY SECONDARY SMELTERS AS REPORTED BY THE U.S. BUREAU OF MINES FOR VARIOUS YEARS In 1,000 kg (Short Tons)[2,3,4]

Product	1966		1967		1970		1971		1973		1974		1975	
Pure Aluminum (≥ 97% Al.)	30,089	(33,168)	49,024	(54,040)	64,295	(70,873)	77,351	(85,265)	109,787	(121,020)	90,343	(99,587)	4,239	(4,673)
Aluminum-Silicon No. 356	18,412	(20,296)	18,309	(20,182)	15,338	(16,907)	16,543	(18,236)	17,762	(19,579)	26,393	(29,094)	21,184	(23,352)
Aluminum-Silicon No. 360	35,646	(39,293)	38,720	(42,682)	42,031	(46,331)	39,882	(43,962)	51,618	(56,899)	45,941	(50,642)	43,017	(47,418)
Aluminum-Silicon (0.6 to 2% Cu.)	7,435	(8,196)	7,700	(8,488)	5,342	(5,889)	4,820	(5,313)	3,611	(3,981)	4,328	(4,771)	4,123	(4,545)
No. 12 and variations	7,860	(8,664)	6,780	(7,474)	7,722	(8,512)	6,032	(6,649)	9,441	(10,407)	19,419	(21,406)	12,095	(13,332)
Aluminum-Copper (≤ 1.5% Si.)	524	(578)	588	(648)	741	(817)	425	(469)	4,200	(4,630)	4,419	(4,871)	4,291	(4,730)
No. 319 and variations	49,559	(54,630)	46,011	(50,719)	45,068	(49,679)	42,580	(46,882)	56,560	(62,347)	47,834	(52,728)	33,022	(36,401)
Nos. 122 and 138	358	(395)	1,216	(1,340)	918	(1,012)	1,215	(1,330)	48	(53)	--		--	
AXS-679 and variations	242,903	(267,756)	259,094	(285,604)	280,206	(308,875)	292,210	(322,106)	367,939	(405,585)	308,666	(340,248)	249,502	(275,030)
Aluminum-Silicon-copper-nickel	24,545	(27,056)	22,450	(24,747)	15,888	(17,508)	15,187	(16,741)	4,238	(4,672)	5,670	(6,250)	3,548	(3,911)
Deoxidizing and other destructive uses:														
Grades 1 and 2	11,247	(12,398)	12,923	(14,245)	15,658	(17,260)	14,307	(15,771)	21,391	(23,580)	24,650	(27,172)	12,909	(14,230)
Grades 3 and 4	14,196	(15,648)	11,949	(13,172)	9,377	(10,336)	7,542	(8,314)	5,889	(6,491)	4,657	(5,134)	2,602	(2,868)
Aluminum-base hardeners	7,196	(7,932)	6,185	(6,818)	4,323	(4,765)	3,885	(4,282)	6,669	(7,351)	4,120	(4,452)	2,897	(3,193)
Aluminum-magnesium	1,216	(1,340)	1,160	(1,279)	710	(783)	799	(881)	3,199	(3,526)	3,843	(4,236)	1,503	(1,657)
Aluminum-zinc	8,970	(9,888)	7,501	(8,268)	4,685	(5,164)	3,750	(4,134)	10,130	(11,166)	9,411	(10,374)	8,215	(9,056)
Miscellaneous	26,755	(29,493)	29,392	(32,399)	21,871	(24,109)	23,689	(26,113)	18,876	(20,809)	16,698	(18,407)	61,125	(67,379)
TOTAL	486,912	(536,731)	519,002	(572,105)	534,169	(588,820)	550,169	(606,457)	691,358	(762,096)	616,394	(679,462)	464,272	(511,775)

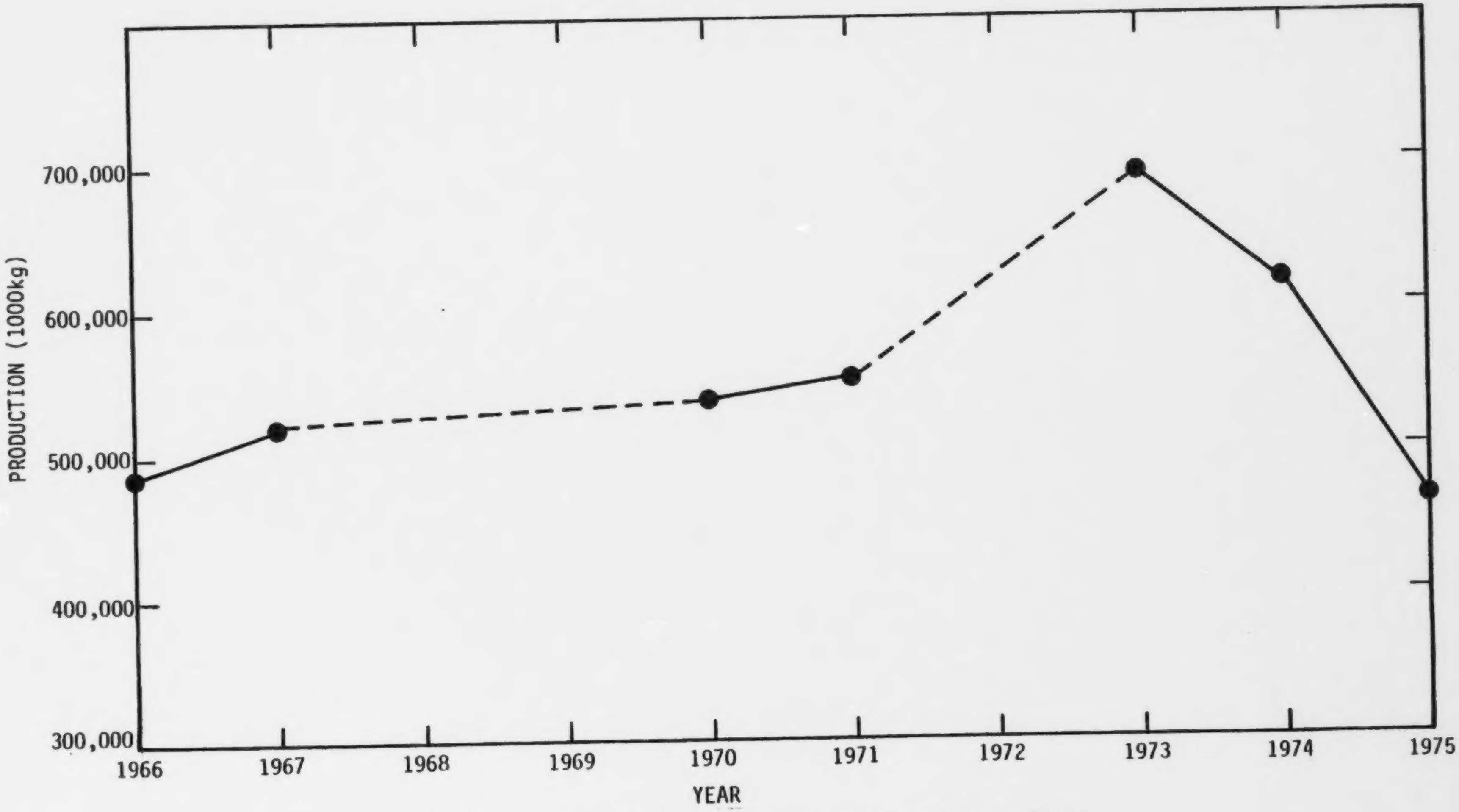

Figure 4-2 Total production of aluminum alloys by secondary smelters

The consumption of new and old scrap by secondary smelters for the years where comparable data was obtained is presented in Table 4-3, while the recovery of secondary aluminum is given in Table 4-4.

Table 4-3. CONSUMPTION OF NEW AND OLD SCRAP BY SECONDARY SMELTERS AS REPORTED BY THE U.S. BUREAU OF MINES FOR VARIOUS YEARS
In 1,000 kg (Short Tons)[2, 4]

Type of Scrap	1970		1971		1973		1974		1975	
New Scrap:										
Segregated low copper (≤ 0.4% CU.)	98,769	(108,874)	110,617	(121,934)	136,815	(150,814)	80,608	(88,856)		
Segregated high copper	12,154	(13,397)	13,250	(14,606)	8,724	(9,617)	10,852	(11,962)		
Mixed low copper	58,904	(64,930)	66,221	(72,996)	88,140	(97,158)	77,789	(85,748)	171,370	(188,904)
High zinc	8,278	(9,125)	5,673	(6,253)	6,069	(6,690)	5,824	(6,420)		
Mixed clips	46,276	(51,010)	41,101	(45,306)	74,071	(81,650)	62,298	(68,672)		
Borings and turnings	145,150	(160,000)	146,964	(162,000)	104,122	(114,775)	87,597	(96,560)	112,881	(124,431)
Foil, dross, skimmings	100,886	(111,208)	86,415	(95,256)	78,132	(86,126)	57,669	(63,569)	85,745	(94,518)
Other	---		---		20,292	(22,368)	18,555	(20,453)	13,194	(14,544)
Total, new scrap	---		---		516,365	(569,198)	401,191	(442,240)	383,190	(422,397)
Old Scrap (solids)	113,985	(125,647)	107,413	(118,402)	101,424	(111,801)	113,345	(124,942)	112,632	(124,156)
Sweated pig (purchased for own use)	42,976	(47,373)	52,747	(58,144)	50,639	(55,820)	57,190	(63,041)	58,955	(64,987)
Total, all scrap	627,373	(691,564)	630,397	(694,897)	668,427	(736,819)	571,726	(630,223)	554,777	(611,540)

Table 4-4. RECOVERY OF SECONDARY ALUMINUM AS REPORTED BY U.S. BUREAU OF MINES

In 1,000 kg (Short Tons)[4]

Year	Type of Scrap			Form of Recovery	
	From New Scrap	From Old Scrap	Total	As Metal	From Alloys and Scrap
1950	151,778 (167,308)	69,270 (76,358)	221,049 (243,666)	1,941 (2,140)	219,108 (241,526)
1951	186,895 (216,017)	69,482 (76,591)	265,448 (292,608)	4,845 (5,341)	260,603 (287,267)
1952	211,607 (233,258)	64,649 (71,264)	276,256 (304,522)	4,442 (4,897)	271,814 (299,625)
1953	262,743 (289,626)	71,613 (78,940)	334,356 (368,566)	4,720 (5,203)	329,636 (363,363)
1954	210,513 (232,052)	54,421 (59,989)	264,934 (292,041)	5,218 (5,752)	259,716 (286,289)
1955	235,524 (259,622)	69,283 (76,372)	304,807 (335,994)	8,185 (9,023)	296,622 (326,971)
1956	243,210 (268,095)	65,020 (71,673)	308,231 (339,768)	8,592 (9,471)	299,639 (330,297)
1957	262,502 (289,360)	65,733 (72,459)	328,235 (361,819)	8,362 (9,218)	319,873 (352,601)
1958	204,504 (225,428)	58,175 (64,127)	262,679 (289,555)	7,188 (7,924)	255,490 (281,631)
1959	255,753 (281,921)	70,765 (78,006)	326,519 (359,927)	14,587 (16,079)	311,932 (343,848)
1960	241,988 (266,747)	56,883 (62,703)	298,870 (329,450)	15,135 (16,684)	283,735 (312,766)
1961	216,008 (238,109)	92,657 (102,137)	308,664 (340,246)	19,552 (21,552)	289,116 (318,698)
1962	302,305 (333,236)	116,591 (128,520)	418,896 (461,756)	31,995 (35,269)	386,900 (426,487)
1963	353,501 (389,670)	105,161 (115,921)	458,662 (505,591)	22,783 (25,114)	435,879 (480,477)
1964	388,286 (428,014)	112,197 (123,677)	500,483 (551,691)	21,890 (24,130)	478,593 (527,561)
1965	436,366 (481,014)	144,880 (159,704)	581,247 (640,718)	23,767 (26,199)	557,479 (614,519)
1966	504,533 (556,155)	124,171 (136,876)	628,704 (693,031)	30,089 (33,168)	598,615 (659,863)
1967	516,409 (569,247)	116,576 (128,504)	632,986 (697,751)	48,676 (53,656)	584,310 (644,095)
1968	600,732 (662,197)	140,351 (154,711)	741,083 (816,908)	65,437 (72,132)	675,646 (744,776)
1969	649,342 (715,781)	84,145 (92,754)	733,487 (808,535)	127,364 (140,395)	606,123 (668,140)
1970	576,824 (635,843)	132,064 (145,576)	708,888 (781,419)	64,295 (70,873)	644,593 (710,546)
1971	588,411 (648,616)	152,195 (167,767)	740,606 (816,383)	77,351 (85,265)	663,256 (731,118)
1972	686,150 (756,355)	171,794 (189,372)	857,945 (945,727)	72,153 (79,535)	785,792 (866,192)
1973	764,379 (842,588)	178,914 (197,220)	943,293 (1,039,808)	109,787 (121,020)	833,506 (918,788)
1974	708,005 (780,446)	193,216 (212,985)	901,221 (993,431)	90,343 (99,587)	810,877 (893,844)
1975	782,896 (863,000)	289,390 (319,000)	(1,072,287 (1,182,000)	420,971 (464,044)	651,315 (717,956)

4.3 GROWTH TRENDS

The secondary aluminum industry was born shortly before World War I at a time when the United States had only one primary aluminum producer. There was little need for a secondary industry prior to that time since the supply of aluminum scrap was limited. Although the secondary industry did grow during World War I and after, that growth was modest until World War II. World War II created many changes in the aluminum industry. The primary industry had changed from a monopoly to one dominated by three companies, while the secondary industry had progressed from a remelter to a smelter. Secondary smelters thus emerged from the war years with the technology needed to process the huge quantities of aircraft scrap and other partially manufactured aluminum products. It was at this point in history that the secondary aluminum industry really started its growth.

The rapid growth of the secondary aluminum industry is best evidenced by the fact that secondary aluminum production increased by 110 per cent between 1960 and 1966. During the same period, primary aluminum production increased by less than 50 per cent. This rapid rate of growth would indicate that the 60's were the real "takeoff" period for the secondary aluminum industry. Before World War II, there were only 25 smelters in the United States, many of which were little more than remelters. Production of secondary aluminum was 72.9×10^6 kg (80,362 tons) in 1940 compared with 628.7×10^6 kg (693,031 tons) in 1966 -- an almost nine-fold increase.[3]

The wartime economy created a huge demand for aluminum, and scrap aluminum assumed crucial importance as a source of the scarce metal. Furthermore, defense needs were for new alloys that had never before existed. Scrap processors and smelter operators were forced to adopt new techniques to remain competitive and make a profit. Thus, much of the technology found in the secondary industry today can be traced to the demand for the alloys, products, and processes that emerged from World War II.

Up to 1975, secondary aluminum annual production volume growth has followed a regular step function pattern of making a 20 per cent increase after about every three years at a steady production rate. It is thus possible to assume, even though the growth in aluminum consumption and primary melting will level off somewhat, that secondary aluminum smelting will grow at the exponential rate of 7 per cent per year. The 1983 production figure should thus be 60 per cent greater than that for 1974 or, roughly, 986 x 10^6 kg (1.09 x 10^6 tons).

This rate of growth, however, does not take into account the current problem of some plants going out of business due to the increased economic cost of pollution control. One industrial contact indicated that their pollution control costs amounted to 75 per cent of their capital investment over the last several years. This industry indicated that should stricter control laws go into effect, they could very possibly be forced to shut down.

This slower growth view is also expressed by the Aluminum Recycling Association. According to them, the capacity of the industry will probably decrease for a few years before increasing again. It will most likely be at the same level in 1983 as it is in 1978. Thus, assuming a 20 per cent growth from 1974 to 1978, the 1983 procution level will be 740 x 10^6 kg (0.82 x 10^6 tons).

The number of secondary smelters in existence has decreased slightly over the past few years due to the economic situation and no evidence of new plant construction could be found. Those companies owning several plants would rather have the older, essentially paid-for plants operate at a wider profit margin than construct new plants that would show only a few-per-cent return on investment.

Evidence of plant modifications,* as defined by the Clean Air act, could not be found aside from the installation of pollution control equipment which would not fall under the "modification" definition.

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* Any physical change in, or change in the method of operation of, a stationary source which increases the amount of any air pollutant emitted by such source or which results in the emission of any air pollutant not previously emitted.

REFERENCES FOR SECTION 4

1. Nadkarni, Ravindra M. Economic Analysis of Effluent Guidelines. The Nonferrous Metals Industry (Aluminum). Environmental Protection Agency. Washington, D.C. Report Number PB-239 161. August 1974.

2. Train, Russell E., Strelow, A. C. Win, and G. S. Thompson, Jr. Development Document for Effluent Limitations Guidelines and New Source Performance Standards for the Secondary Aluminum Smelting Subcategory of the Nonferrous Metals Manufacturing Point Source Category. U.S. EPA, Washington, D.C. Report Number PB-238 464. March 1974. 131 p.

3. Siebert, Donald L. Impact of Technology on the Commercial Secondary Aluminum Industry. U.S. Department of the Interior. Washington, D.C. Information Circular 8445. 1970. 74 p.

4. Aluminum Profile. Metal Statistics 1976. American Metal Market. p. 21-37.

5. Talley, Ronald J. and R. H. Ongerth. Aluminum as a Component of Solid Waste and a Recoverable Resource. National Environmental Research Center. Cincinnati, Ohio. Report Number PB-235 770. September 1974. 30 p.

5. SECONDARY ALUMINUM MANUFACTURING PROCESSES

For the purposes of this document, the secondary aluminum industry is defined as that portion of the secondary nonferrous metals industry which recovers, processes, and remelts various grades of aluminum-bearing scrap to produce metallic aluminum or an aluminum alloy as a product. This does not include the casting or allying or remelting billets, ingots, or pigs, nor those operations of the primary aluminum industry which recycle certain categories of scrap.

The recovery of aluminum from various forms of aluminum scrap involves four rather distinct operations. These are:

1. Collection, sorting, and transporting.
2. Presmelting preparation.
3. Charging, smelting, and refining.
4. Pouring the product line.

Figure 5-1 presents a generalized flowsheet of secondary aluminum industry operations. The flowsheet includes: Initial collection of aluminum-bearing scrap, presmelting preparation, scrap concentration, scrap charging into the furnace for melting, refining of the melt by demagging and addition of alloying agents, and, finally, pouring of the product line. Each of these operations is described in the following sections.

5.1 COLLECTION, SORTING, AND TRANSPORTING

Nearly 95 per cent of the secondary smelting raw materials is supplied from scrap aluminum purchased from scrap dealers and industrial plants. Classifications and chemical analysis of the scrap have been specified by the Aluminum Smelters Research Institute (ASRI) (now the Aluminum Recycling Association). Table 5-1 gives the ASRI classifications. It should be noted that nowhere in the classification and grading of aluminum scrap is there a mention

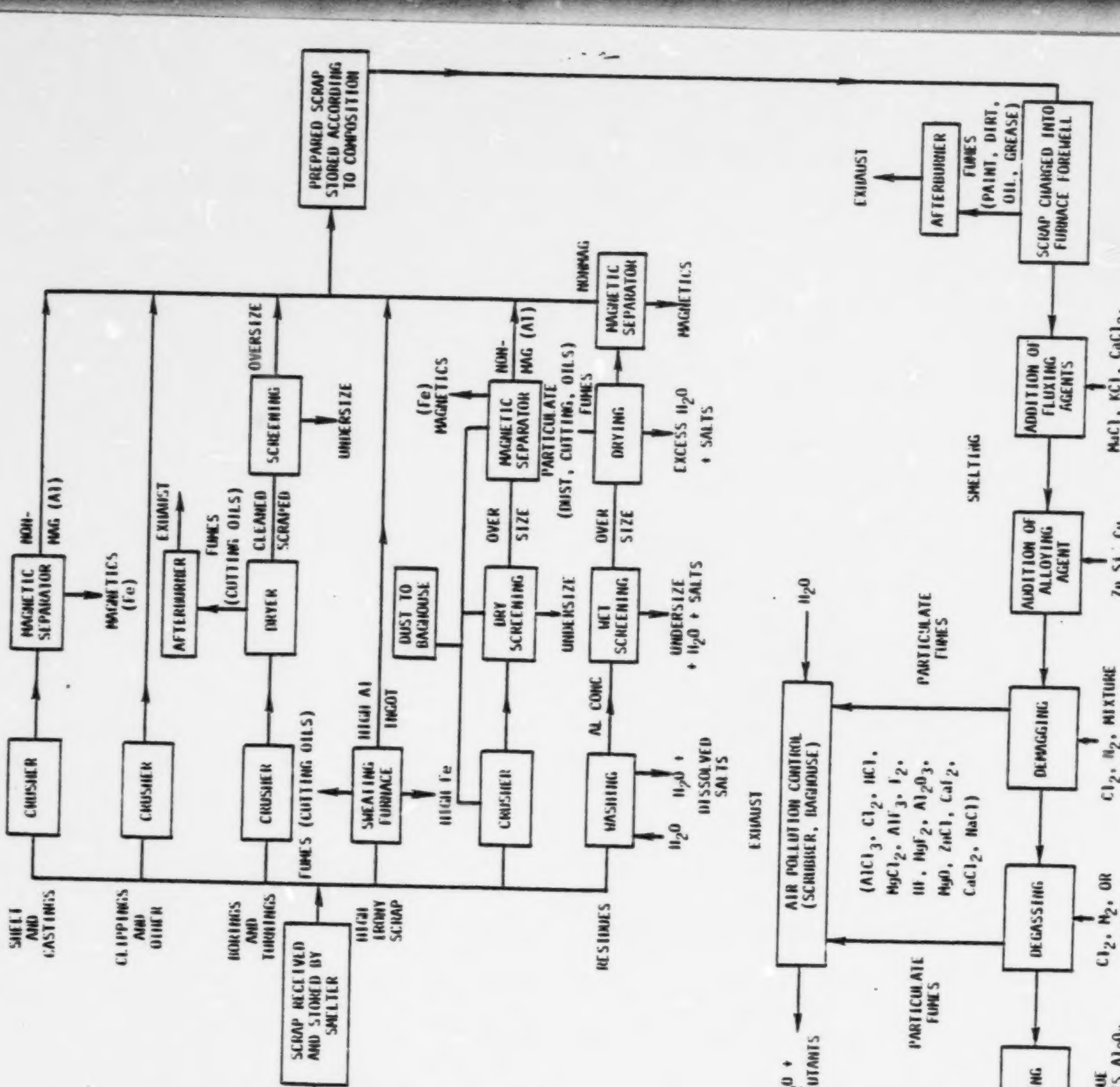
Al
Cu
Zn
Pb
ETC
Al SCRAP PRODUCER
COLLECTOR
MIXTURE OF SCRAP
DEALER SORTS SCRAP
SCRAP RECEIVED AND STORED BY SMELTER
SHEET AND CASTINGS
CLIPPINGS AND OTHER
BORINGS AND TURNINGS
HIGH IRONY SCRAP
RESIDUES
CRUSHER
CRUSHER
CRUSHER
FUMES (CUTTING OILS)
SWEATING FURNACE
HIGH Al INGOT
HIGH Fe
CRUSHER
WASHING
H_2O
H_2O + DISSOLVED SALTS
AL CONC
MAGNETIC SEPARATOR
MAGNETICS (Fe)
NON-MAG (Al)
AFTERBURNER
EXHAUST
FUMES (CUTTING OILS)
DRYER
CLEANED SCRAPED
SCREENING
OVERSIZE
UNDERSIZE
DUST TO BAGHOUSE
DRY SCREENING
UNDERSIZE
OVER SIZE
MAGNETIC SEPARATOR
(Fe) MAGNETICS
NON-MAG (Al)
PARTICULATE (DUST, CUTTING, OILS) FUMES
WET SCREENING
UNDERSIZE + H_2O + SALTS
OVER SIZE
DRYING
EXCESS H_2O + SALTS
NONMAG
MAGNETIC SEPARATOR
MAGNETICS
PREPARED SCRAP STORED ACCORDING TO COMPOSITION
SCRAP CHARGED INTO FURNACE FOREWELL
FUMES (PAINT, DIRT, OIL, GREASE)
AFTERBURNER
EXHAUST
ADDITION OF FLUXING AGENTS
NaCl, KCl, $CaCl_2$, Na_3AlF_6
SMELTING
ADDITION OF ALLOYING AGENT
Zn Si, Cu, Mg, ETC.
DEMAGGING
Cl_2, N_2, MIXTURE AlF_3, $AlCl_3$
PARTICULATE FUMES
H_2O
AIR POLLUTION CONTROL (SCRUBBER, BAGHOUSE)
EXHAUST
($AlCl_3$, Cl_2, HCl, $MgCl_2$, AlF_3, I_2, HF, MgF_2, Al_2O_3, MgO, ZnCl, CaF_2, $CaCl_2$, NaCl)
DEGASSING
Cl_2, N_2, OR MIXTURE
PARTICULATE FUMES
H_2O + POLLUTANTS
SKIMMING
RESIDUE FLUXING SALTS Al_2O_3
INGOTING EXTERNAL COOLING
H_2O
H_2O
INGOTING INTERNAL COOLING
H_2O
H_2O
INGOTING AIR COOLED
SHOT QUENCHING
H_2O
H_2O
SIZING
OVERSIZE BACK TO FURNACE
PACKAGING SHIPMENT
STACKING STORAGE SHIPMENT

Figure 5-1 The total secondary aluminum process

Table 5-1 A.S.R.I. ALUMINUM SCRAP CLASSIFICATIONS

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CLASSIFICATIONS:

1. NEW PURE ALUMINUM CLIPPINGS: Shall consist of new, clean, unalloyed sheet clippings and/or aluminum sheet cuttings, free from oil, grease, foil and any other foreign substance and from punchings less than one-half inch in size.

2. NEW PURE ALUMINUM WIRE AND CABLE: Shall consist of new, clean, unalloyed aluminum wire or cable free from hair wire, wire screen, copper, iron, insulation and any other foreign substance.

3. OLD PURE ALUMINUM WIRE AND CABLE: Shall consist of old, unalloyed aluminum wire or cable containing not over 1 per cent free oxide or dirt and free from hair wire, wire screen, copper, iron, insulation and any other foreign substance.

4. SEGREGATED NEW ALUMINUM ALLOY CLIPPINGS: Shall consist of new, clean, uncoated aluminum clippings of one specified aluminum alloy only, free from hair wire, wire screen, foil, can stock, stainless steel, iron, dirt, oil, grease and any other foreign substance, and from punchings less than one-half inch in size.

5. MIXED NEW ALUMINUM ALLOY CLIPPINGS: Shall consist of new, clean, uncoated aluminum clippings of two or more alloys, none of which shall be alloys containing zinc in excess of .25% (such as 7,000 series), tin in excess of .30%, and/or magnesium in excess of 2.80%. To be free from hair wire, wire screen, foil, can stock, stainless steel, iron, dirt, oil, grease and/or any other foreign substance. Shall not contain punchings less than one-half inch in size.

6. MIXED LOW COPPER ALUMINUM ALLOY CLIPPINGS: Shall consist of new, clean, uncoated aluminum clippings of two or more alloys, none of which shall exceed a maximum of .40% copper, .25% zinc, .30% tin, and 2.80% magnesium, and shall be free from tin-containing alloys, hair wire, wire screen, stainless steel, iron, dirt, oil, grease and/or any other foreign substance, and shall be free from punchings less than one-half inch in size.

7. SEGREGATED OLD ALUMINUM ALLOY SHEET: Shall consist of clean, uncoated, old aluminum sheet of one specified alloy only, free from wrecked airplane sheet, hair wire, wire screen, foil, stainless steel, iron, dirt, oil, grease and any other foreign substance.

8. MIXED OLD ALLOY SHEET: Shall consist of clean, uncoated, old alloy sheet aluminum of two or more alloys not to contain wrecked airplane sheet and to be free from hair wire, wire screen, oil cans, foil, food or beverage containers, stainless steel, iron, dirt, oil, grease and all other foreign substances.

9. SCRAP SHEET AND SHEET UTENSIL ALUMINUM: Shall consist of clean, uncoated manufactured sheet aluminum, free from stainless steel, iron, dirt, or any other foreign substances and to be free from hub caps, radiator shells, airplane sheet, foil, food or beverage containers, pie plates, oil cans, bottle caps, and lawn furniture.

10. SEGREGATED NEW ALUMINUM CASTINGS, FORGINGS, AND EXTRUSIONS: Shall consist of new, clean, uncoated aluminum castings, forgings and extrusions of one specified alloy only and to be free from sawings, stainless steel, zinc, iron, dirt, oil, grease and any other foreign substance.

11. MIXED NEW ALUMINUM FORGINGS AND EXTRUSIONS: Shall consist of clean, new, uncoated aluminum forgings and extrusions of two or more alloys, none of which shall be alloys containing zinc in excess of .25% (such as 7,000 series), tin .30% and/or magnesium in excess of 2.80%. Shall also be free from sawings, stainless steel, zinc, iron, dirt, oil, grease and any other foreign substance.

12. MIXED NEW ALUMINUM CASTINGS: Shall consist of clean, new, uncoated aluminum castings of two or more alloys, none of which shall exceed 3% zinc, .50% tin, and/or magnesium in excess of 2.80%. Shall be free of sawings, stainless steel, iron, dirt, oil, grease, and any other foreign substances.

13. ALUMINUM AUTO CASTINGS: Shall consist of all clean automobile aluminum castings of sufficient size to be readily identified and to be free from iron, dirt, brass, babbitt bushings, brass bushings and any other foreign materials. Oil and grease not to exceed 2%.

14. ALUMINUM AIRPLANE CASTINGS: Shall consist of clean aluminum castings from airplanes and to be free from iron, dirt, brass, babbitt bushings, brass bushings and any other foreign materials. Oil and grease not to exceed 2%.

15. MIXED ALUMINUM CASTINGS: Shall consist of all clean aluminum castings which may or may not contain auto and airplane castings, but no ingots, and to be free from iron, dirt, brass, babbitt and any other foreign materials. Oil and grease not to exceed 2%.

16. ALUMINUM PISTONS:

(a) CLEAN ALUMINUM PISTONS: Shall consist of clean aluminum pistons to be free from struts, bushings, shafts, iron rings and any other foreign materials. Oil and grease not to exceed 2%.

(b) ALUMINUM PISTONS WITH STRUTS: Shall consist of clean whole aluminum pistons with struts to be free from bushings, shafts, iron rings and any other foreign materials. Oil and grease not to exceed 2%.

(c) IRONY ALUMINUM PISTONS: Should be sold on recovery basis, or by special arrangements with purchaser.

17. WRECKED AIRPLANE SHEET AND/OR BREAKAGE ALUMINUM: Should be sold on recovery basis, or by special arrangements with purchaser.

18. NEW ALUMINUM FOIL: Shall consist of clean, new, pure, uncoated, unalloyed aluminum foil, free from etched radar foil, paper, dirt, lead, stainless steel, iron, tin, solder, plastic or any other foreign materials. Should not be packed in hydraulic briquettes.

19. OLD ALUMINUM FOIL: Shall consist of clean, old, uncoated, pure, unalloyed aluminum foil, free from etched and radar foil, paper, dirt, lead, stainless steel, iron, tin, solder, plastic or any other foreign materials. Should not be packed in hydraulic briquettes

20. ALL OTHER ALUMINUM BASE FOILS INCLUDING ETCHED FOIL, RADAR FOIL AND CHAFF: Should be sold by special arrangements with purchaser.

21. SEGREGATED ALUMINUM BORINGS AND TURNINGS: Shall consist of clean, uncorroded aluminum borings and turnings of one specified alloy only and subject to deductions for fines in excess of 3% through a 20 mesh screen and dirt, free iron, oil, moisture and all other foreign materials. Material containing iron in excess of 10% and/or any free magnesium or stainless steel or containing highly flammable cutting compounds, will not constitute good delivery.

22. MIXED ALUMINUM BORINGS AND TURNINGS: Shall consist of clean, uncorroded aluminum borings and turnings of two or more alloys and subject to deductions for fines in excess of 3% through a 20 mesh screen and dirt, free iron, oil, moisture and all other foreign materials. Material containing iron in excess of 10% and/or any free magnesium or stainless steel or containing highly flammable cutting compounds, will not constitute good delivery. To avoid dispute should be sold on basis of definite maximum zinc, tin and magnesium content.

23. SWEATED ALUMINUM: Shall consist of aluminum scrap which has been sweated or melted into a form or shape such as an ingot, pig or slab for convenience in shipping; to be free from corrosion, drosses or any foreign materials. Should be sold subject to sample or analysis.

24. ALUMINUM GRINDINGS: Should be sold on recovery basis, or by special arrangements with purchaser.

25. ALUMINUM DROSSES, SPATTERS, SPILLINGS, SKIMMINGS AND SWEEPINGS: Should be sold on recovery basis, or by special arrangements with purchaser.

26. ALUMINUM HAIR WIRE: Should be sold by special arrangements with purchaser.

27. ALUMINUM WIRE SCREEN: Should be sold by special arrangements with purchaser.

28. COATED ALUMINUM (PAINTED OR PLASTIC COATED, ETC.): Should be sold by special arrangements with purchaser. Siding, awnings, and venetian blinds should each be packaged separately.

29. CONTAINERS OF ALL TYPES (OIL, FOOD, BEVERAGE, AEROSOL): Should be sold by special arrangements with the purchaser, and should each be packaged separately.

30. ITEMS NOT COVERED SPECIFICALLY BY ABOVE CLASSIFICATIONS. Any new item which might appear and which is not covered specifically by above classifications should be discussed and sold by special arrangements with the purchaser.

of the magnesium content. Only the levels of copper, silicon, zinc, and iron are given. The reason for this practice is that magnesium can be removed from the alloy by chemical action (demagging), while the others, because of their lower reactivity, cannot be removed by chemical action. Adjustment to concentration of elements other than magnesium is done by dilution or blending with pure aluminum.

The scrap used by the secondary smelters can be divided into five main groups:

1. Old castings and sheet.
2. New clippings, forgings, and other solids.
3. Borings and trimmings.
4. Residues.
5. High iron (sweated pig).

Old castings and sheet come from many sources, such as automobile parts, household items, and dismantled airplanes. New clippings, forgings, and other solids originate from the aircraft industry, fabricators, industry manufacturing plants, and government manufacturing plants. Borings and turnings are derived mainly from the machining of castings, rods, and forgings by the aircraft and automobile industries. Residues (dross, skimmings, and slag) originate from melting operations at primary reduction plants, secondary smelting operations, casting plants, and other foundries. High iron scrap comes from many miscellaneous sources and requires treatment in sweat furnaces to concentrate the aluminum. This may be done by the dealer or secondary smelter.

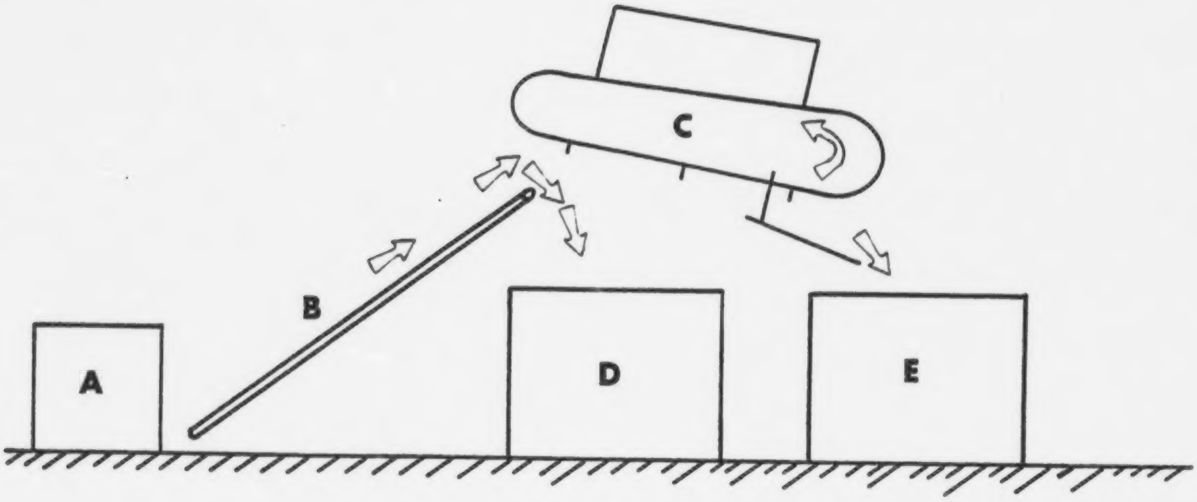
The scrap dealer sorts the collected aluminum scrap into groups of similar composition and physical shape. Sheet, extruded material, and castings are often compressed and baled into 0.91 x 1.83 m (3 x 6 ft.) bundles. Borings and turnings are often formed into briquettes. These various types of scrap are then typically shipped loosely in large bins. Some secondary aluminum smelters have accounts with scrap producers and receive segregated shipments directly without dealer handling.

5.2 PRESMELTING PREPARATION

The bales of sheet and castings are usually unloaded from trucks or railroad cars and moved by conveyor directly into a huge hammer mill. Obvious pieces of magnesium or contaminating metals that might accidentally be in the scrap are hand picked from the material before the high-speed hammer mill fragments the scrap into pieces smaller than the average-sized fist. The fragmented material is then passed over a magnetic separator (Figure 5-2) which removes the tramp iron that has been liberated by the crusher. Metallic iron and other contaminants are collected, weighed, and subtracted from the weight of the shipment. The aluminum fraction is collected in portable containers (tote boxes), weighed, sampled, and tagged for future identification and use. Payment to the dealer is based upon the weight of aluminum scrap that remains after crushing and magnetic separation.

Aluminum clippings are created when sheet aluminum is punched or stamped to form various parts for fabrication. Circular beverage container lids are manufactured by this method and the perforated sheet that remains after punching is sold as clippings. Often this scrap is so pliable and intertwined that it is extremely difficult to handle and it is necessary to put the material through a hammer mill to fragment it into smaller pieces. The material can also be hydraulically compressed or baled. Other aluminum solids such as extrusions or containers are identified, weighed, sampled, and tagged for future consumption.

Aluminum borings and turnings are the waste products of machinery and drilling and are often heavily contaminated with cutting oils. In spite of



LEGEND

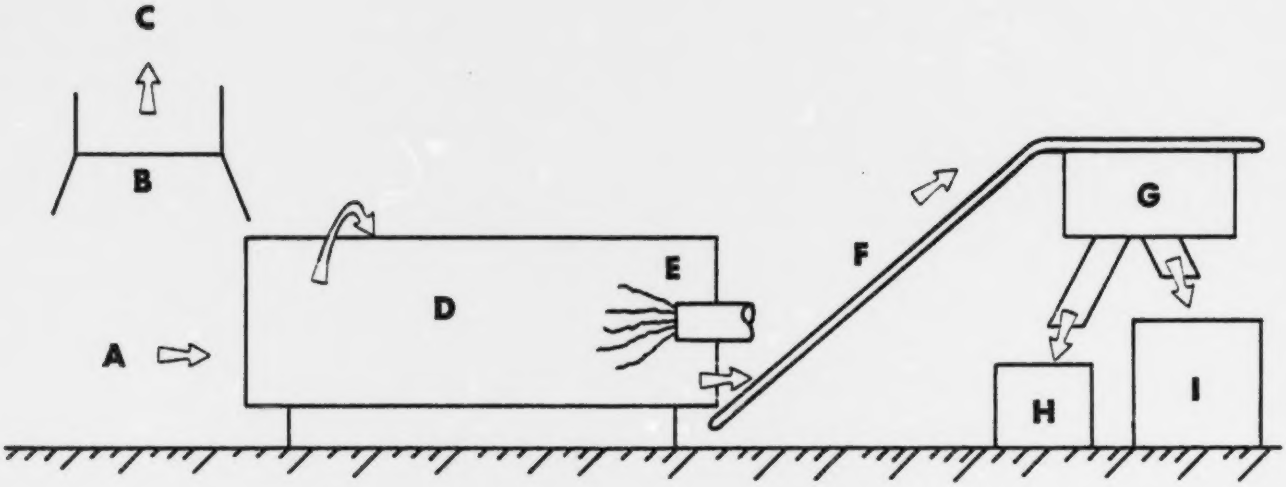
A - MATERIAL TO BE SORTED (BALES OF SCRAP)
B - CONVEYOR
C - ROTARY MAGNET
D - NON-METALLICS (ALUMINUM)
E - METALLICS (SCRAP CONTAINING IRON)

Figure 5-2. Magnetic separator

this fact, some plants charge this material directly into the smelter forewell. Most plants, however, pretreat this material. Like clippings, this scrap is also received in long intertwined pieces and must be crushed in a hammer mill. The crusher discharge is then fed into a gas- or oil-fired rotary dryer which removes the cutting oils, contaminating organic compounds and water. The dryer discharge is usually screened to remove the fines and then passed over a magnetic separator to remove the tramp iron. A typical dryer is shown schematically in Figure 5-3.

Any freshly-exposed surface of aluminum will oxidize instantly in the presence of air and form a highly protective coating which retards further oxidation. This coating forms so rapidly on molten aluminum that it builds up into an oxide skin called "dross." This dross must be skimmed from the metal before the molten aluminum is cast into ingots to prevent oxide inclusion. Skimmings, which are composed of the drosses and slag (fluxing salts), contain various amounts of aluminum (10-30 percent) and can be reprocessed to recover the economic value of the included metal.

In general, these residue products are processed by either of two methods, wet or dry. More commonly used is the dry method in which residue material is crushed, screened to remove the fines, and passed over a magnetic separator to remove the iron. Screen oversize is then ready for reuse. In the wet method, the residue material is fed into a long tumbling drum and a stream of water passing through the drum washes the residue and carries away all of the fluxing salts and chemicals. The discharge is then screened, dried, and passed over a magnetic separator before recycling. Slags are usually processed by the wet method since they are composed of fluxing salts. Other residues not containing fluxing salts are usually processed by the dry method. Both methods have disadvantages; for example, water from the system



LEGEND

A - CONTAMINATED SCRAP LOADED BY HAND OR LOADER
B - HOOD TO CONTAIN DUST
C - EXHAUST TO AFTERBURNER OR BAGHOUSE
D - ROTARY DRUM DRYER
E - HEAT SOURCE
F - SHAKER CONVEYOR
G - MAGNETIC SEPARATOR
H - METALLICS (IRON)
I - NON-METALLICS (ALUMINUM)

Figure 5-3. Secondary aluminum chip dryer with magnetic separator

in the wet method is a potential source of water pollution, and high volumes of dust are generated by the dry method.

Because of additional equipment needed, the technical knowledge required, and specialized processing problems involved, the processing of residue is limited to larger smelters. Large smelters continually purchase residue products from small smelters not equipped to process their own. Residue products are always purchased on the basis of analysis and metal recovery.

Aluminum scrap containing considerable amounts of iron generally is pretreated to reduce the amount of the iron. This processed scrap, called sweat pig, can be either purchased from dealers or produced from high-iron material that the smelter operator purchases from scrap dealers. The scrap charged to an aluminum sweating furnace may include any one or a combination of the following: Aircraft engines, seats, and wreckage; painted aluminum sheet metal; insulated wire; automotive parts; etc. The high-iron scrap is treated by heating to above 1033°K (1400°F)[1] in a sloping hearth or grate furnace which is direct fired by oil or natural gas (a "sweating furnace"). The aluminum melts, flows away from the residual iron, and is cast into pigs (sweated pigs) or sows.

The choice of scrap that a secondary smelter purchases for use in its furnaces is determined by the equipment or flowsheet of the individual smelter. Obviously, a smelter with no dryer for processing oily borings and turnings cannot use this material. Likewise, smelters without crushing or residue processing equipment are similarly restricted in the type of scrap they can process. Air pollution codes in many cities have also limited the use of heavily painted material such as painted siding or venetian blinds. Hence, smelters having limited processing equipment must be selective in scrap purchasing while more sophisticated smelters can buy relatively indiscriminately and take advantage of lower prices.

5.3 SMELTING

Secondary aluminum melting is a batch process of charging, melting, fluxing and pouring operations. A "heat" can vary from 4 to 72 hours. Most medium-to-large secondary aluminum melting operations take place in reverberatory furnaces. These furnaces are usually gas- or oil-fired and range in capacity from 9100 to 82,000 kg (10 to 90 tons) or greater.[2] A charging well is frequently used on aluminum reverberatory furnaces, which permits chips and other aluminum scrap to be charged and immersed below the liquid level. The charging well can also be used as a point to flux the molten metal with a gaseous halogen flux. It is desirable to use a submerged type hood in the charging well to efficiently exhaust the acid gases generated during fluxing. A typical furnace is pictured in Figure 5-4.

Rotary furnaces have also been tried by some companies in the past and have proven successful in processing high-metallic raw materials. The principal disadvantages of a rotary furnace are low capacity and unsuitability for alloying and producing a homogeneous product. The principal advantages of a rotary furnace over a reverberatory furnace are a controlled pouring rate and mechanical mixing action. By adjusting the tilt of the rotary furnace, the pouring rate of the molten metal is always under the control of the operator. This feature makes a rotary furnace exceptionally safe to work with. When a reverberatory furnace is tapped for pouring, it is sometimes difficult to stop the flow of molten metal if an emergency arises. For melting small quantities of aluminum, up to 454 kg (1000 pounds), crucible or pot-type furnaces are used extensively.[2] Almost all crucibles are made of silicon carbide or similar refractory material.

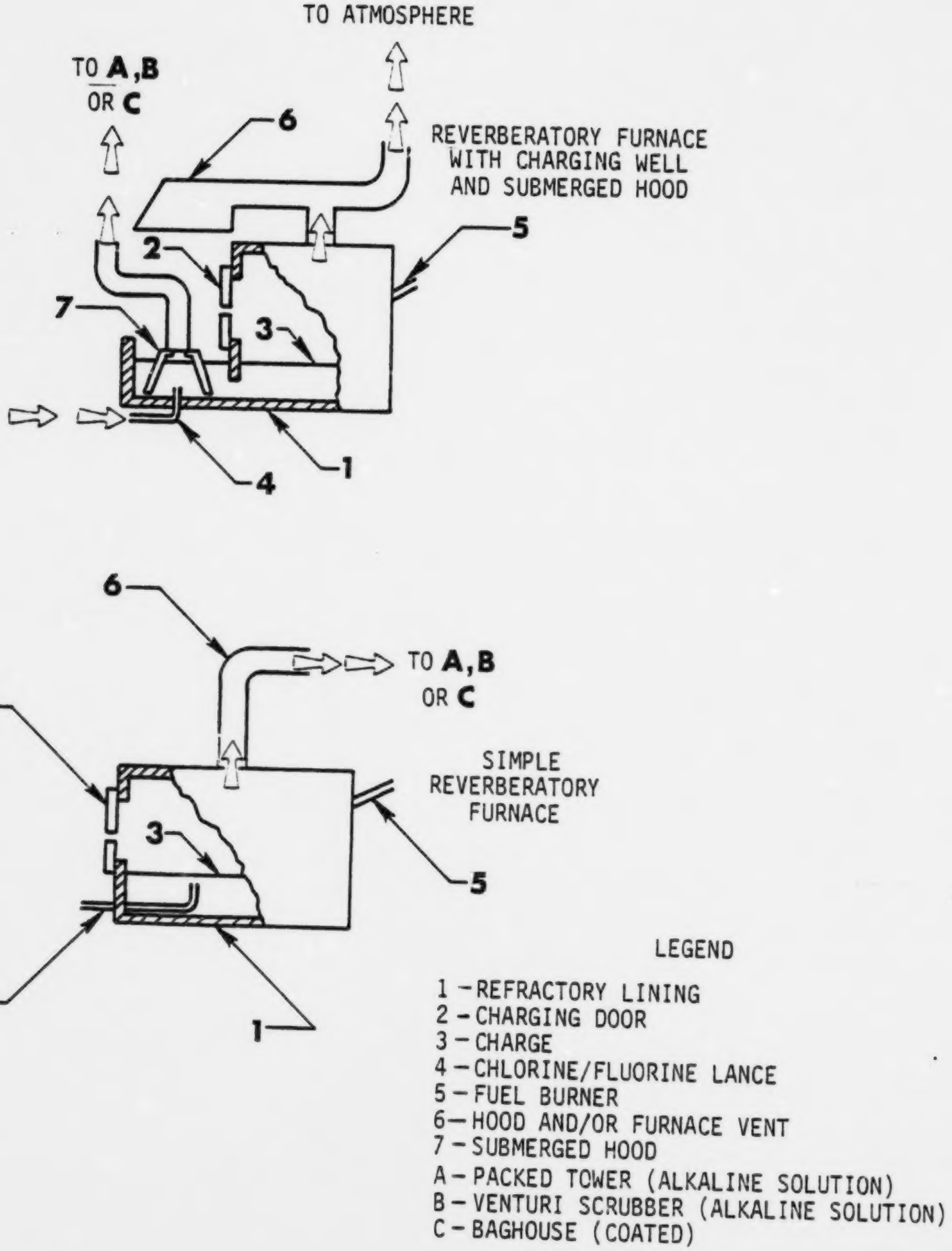

TO ATMOSPHERE
TO A,B OR C
6
REVERBERATORY FURNACE WITH CHARGING WELL AND SUBMERGED HOOD
2
5
7
3
4
1
6
TO A,B OR C
2
SIMPLE REVERBERATORY FURNACE
3
5
4
1
LEGEND
1 - REFRACTORY LINING
2 - CHARGING DOOR
3 - CHARGE
4 - CHLORINE/FLUORINE LANCE
5 - FUEL BURNER
6 - HOOD AND/OR FURNACE VENT
7 - SUBMERGED HOOD
A - PACKED TOWER (ALKALINE SOLUTION)
B - VENTURI SCRUBBER (ALKALINE SOLUTION)
C - BAGHOUSE (COATED)

Figure 5-4. Secondary aluminum smelting in reverberatory furnace[4]

Generally, the smelting of aluminum scrap with reverberatory furnaces consists of six operations or tasks. These are the following:

1. Charging scrap into the furnace.
2. Addition of fluxing agents.
3. Addition of alloying agents.
4. Mixing/degassing.
5. Removal of magnesium (demagging).
6. Skimming.

Any given smelter may not incorporate all six steps or follow the above order. There is also some variability in the secondary industry as to precise techniques used in each step. Each of these steps is discussed in the following sub-sections.

5.3.1 Charging

Scrap may be charged continuously into the furnace, with simultaneous pouring, or may be loaded in batches. Deoxidant producers, not particularly concerned about the exact composition of the melt, often use continuous loading. Specification alloy producers, however, need to maintain a critical compositional range through selective melt additions and thus are confined to batch loadings. Often, residual melt ("heel") is left in the reverbatory to facilitate melting of the new charge. This results in a shortened heating cycle. The heel also results in less variability in composition from batch to batch.

Forklifts or front-end loaders are used to charge the furnace through the forewell with the various types of scrap. Depending on the capacity of the furnace, which can range from 9100 to 82,000 kg (10 to 90 tons), it takes 4 to 75 hours to fully charge a furnace, with the average being 24 hours. Each complete smelting cycle is called a heat. The time required for each heat is dependent on the materials charged, size and design of furnace, heat input, fluxing procedures, and alloying practices.

5.3.2 Fluxing

The addition of a covering flux to the molten aluminum melt forms a barrier for gas absorption and oxidation of the metal. The flux also reacts with non-metallics, residues from burned coating, and dirt in the scrap. It collects such impurities and allows physical separation from the molten aluminum. The exact composition of the flux cover used varies from smelter to smelter but is generally some combination containing one or more of the following: Sodium chloride, potassium chloride, calcium chloride, calcium fluoride, aluminum fluoride, and cryolite. A common flux mixture is 47.5 per cent sodium chloride, 47.5 per cent potassium chloride, and 5 per cent cryolite.[3] At the melting point of aluminum, the fluxes usually range from a tacky semi-solid to a liquid, depending on the composition of the mixture and the technique used to remove it from the melt.

The amount of flux used depends primarily on the material charged. Scrap containing a relatively large surface area, such as borings and turnings, creates large amounts of oxides and requires proportionally larger amounts of flux. The flux generally is added along with the aluminum scrap in amounts from less than 10 per cent to 33 per cent by weight of the material charged.[1]

5.3.3 Alloying

Alloying agents, normally added to the aluminum melt, include copper, silicon, manganese, magnesium, and zinc. Usually these are added after the furnace has been charged with aluminum scrap and analyzed for its composition. The amounts of additions required to bring it up to specifications are then added. These additions are usually scrap, which is high in the concentration of the desired element or, as in the case of silicon, in the pure state. These are added to the forewell and stirred into the melt with an inert gas (N_2). The addition of the alloying agents and the stirring produces no solid waste and only minor amounts of fumes and dust that are removed from the working area by the hoods over the forewell.

5.3.4 Mixing/Degassing

Mixing of the metal to insure uniform composition and to agitate the solvent fluxes into the melt is generally accomplished by injecting nitrogen gas. Aside from homogenizing the melt, the mixing step is beneficial in bringing to the surface dissolved gases, such as hydrogen, and intermixed solids. Once on the surface, the impurities combine with the fluxing agent and can be skimmed off.

Mixing is performed nearly continuously in the reverberatory furnace. Mixing often does double duty and serves as a degassing operation. In such cases, a mixture of nitrogen and chlorine (90 per cent-10 per cent) is often used.[1] The mixing operation employs no water and produces no solid wastes. Only when the mixture of nitrogen and chlorine is used are fumes generated.

5.3.5 Magnesium Removal (Demagging)

Scrap aluminum, received by the secondary smelters, averages about 0.3 to 0.5 per cent magnesium, while the product line of alloys produced averages about 0.1 per cent.[1] Therefore, after the furnace is fully charged and the melt brought up to the desired chemical specification, it is usually necessary to remove the excess magnesium. This is done with chlorine or chlorinating agents, such as anhydrous aluminum chloride or chlorinated organics, or with aluminum fluoride. Magnesium chloride or magnesium fluoride is formed and collected in the fluxing agents on top of the molten melt. The reactions that take place are the following:

Chlorination: $Mg + Cl_2 \rightarrow Mg\ Cl_2$
Fluoridation: $2AlF_3 + 3\ Mg \rightarrow 2\ Al + 3MgF_2$

Magnesium is the only metal removable from the alloy in this manner. Other metal levels must be adjusted by the addition of either more aluminum or more of the metal

5.3.6 Skimming

The contaminated semi-solid fluxing agent, known as slay, is removed from the surface of the melt in the forewell, usually with a perforated ladle or similar device that permits molten metal to drain back into the forewell. This is done just before tapping the reverberatory furnace to pour ingots. The slag is placed in pans to cool or in an internally water-cooled dross cooler. Once cooled, the slag is either stored until shipped to a residue processor, reprocessor, reprocessed by the company, or dumped.

5.4 POURING

After the furnace has been completely charged, the specification composition reached by blending and demagging, and the melt degassed and skimmed, the molten metal is cooled to around 1005°K (1350°F) for pouring.[1] Pouring practices are dependent upon the company's product line and its type of furnace. Large reverberatory furnaces are either tapped from a tap hole or siphoned into a ladle. Ladles vary up to 2720 or 3630 kg (3 or 4 tons) capacity in some cases. Small crucibles are lifted out of the furnace and used as ladles to pour into molds. The larger crucibles are usually used with tilting-type furnaces.

REFERENCES FOR SECTION 5

1. Train, Russell E., R. Strelow, A. C. Win, and G. S. Thompson, Jr. Development Document for Effluent Limitations Guidelines and New Source Performance Standards for the Secondary Aluminum Smelting Subcategory of the Nonferrous Metals Manufacturing Point Source Category. U.S. EPA, Washington, D.C. Report Number PB-238 464. March 1974. 131 p.

2. Secondary Aluminum-Melting Processes. In: Air Pollution Engineering Manual. U.S. Environmental Protection Agency. Washington, D.C. Report Number AP-40. May 1973. p. 283-292.

3. Siebert, Donald L. Impact of Technology on the Commercial Secondary Aluminum Industry. U.S. Department of the Interior. Washington, D.C. Information Circular 8445. 1970. 74 p.

4. Lanber, J. D., Conley, F. W., and Barshield, R. D. Air Pollution Control of Aluminum and Copper Recycling Processes. Pollution Engineering. 5: 23-26. December 1973. pp. 23-26.

6. SECONDARY ALUMINUM MANUFACTURING AIR EMISSION SOURCES AND CONTROLS

The following two sections describe the sources of air emissions in the secondary aluminum manufacturing process and the types of control devices used to reduce these emissions.

6.1 EMISSIONS SOURCES AND TYPES

The secondary aluminum industry generates air emissions primarily from its presmelting preparation and smelting operations. Presmelting preparation sources of air emissions include high iron scrap sweating furnaces, borings and turnings scrap dryers, and dry residue milling machines. Smelting operations that generate air emissions include charging, fluxing, and demagging. In addition to these main sources, there are a few miscellaneous sources of air emissions associated with the manufacturing process. Table 6-1 identifies the primary air emission sources and pollutants. These are further described in the following subsections.

6.1.1 Presmelting Sources

In theory, an aluminum sweating furnace can be operated with minor emissions of air contaminants if clean, carefully hand-picked metal free of organic material is processed. In practice, this selective operation does not occur and high emissions periodically result from the furnaces. Smoke is caused by the incomplete combustion of organic constituents such as rubber, oil and grease, plastics, paint, cardboard, and paper. Fumes are produced from the oxidation of zinc and magnesium contaminants.

Table 6-1. SECONDARY ALUMINUM MANUFACTURING OPERATIONS PRIMARY AIR EMISSION SOURCES AND POLLUTANTS

Process Operation	Air Emission Source	Pollutant(s)
Presmelting Preparation	High Iron Scrap Sweating Furnace	Unburned hydrocarbons, carbonaceous particulate, inorganic particulate, CO
	Borings and Turnings Scrap Dryer	Unburned hydrocarbons, carbonaceous particulate, inorganic particulate, CO
	Dry Residue Milling Machines	Inorganic particulate
Smeling Operations		
- Charging	Furnace forewell	Unburned hydrocarbons, carbonaceous particulate, inorganic particulate, CO
- Fluxing	Furnace	Particulate (such as $CaCl_2$, NaCl)
- Demagging	Furnace	a) Chlorine (Cl_2), aluminum chloride ($AlCl_3$), hydrogen chloride (HCl), magnesium chloride ($MgCl_2$), inorganic particulate or b) Hydrogen fluoride (HF), aluminum fluoride (AlF_3) magnesium fluoride (MgF_2), inorganic particulate

a) Pollutants resulting from chlorine demagging.

b) Pollutants resulting from fluoride demagging.

In order to avoid the production of black smoke during melting and refining, many plants thermally treat their aluminum borings and turnings in a dryer. These borings and turnings are contaminated with oils and other organic compounds. The exhausts from these dryers can contain significant amounts of fume composed of unburned hydrocarbons and other gaseous and particulate carbon compounds.

Residues used by the secondary aluminum industry are generally composed of 10 to 30 percent aluminum, with occluded aluminum oxide fluxing salts (mostly NaCl and KCl), dirt and various other chlorides, fluorides, and oxides. In the dry milling process used to separate metals from nonmetals, dust (inorganic particulate) is generated at the crusher, in the mill, at the shaker screen and at points of transfer.

6.1.2 Smelting Sources

The major sources of air emissions from secondary aluminum smelting operations occur during charging, fluxing, and demagging. During charging, black carbonaceous smoke is emitted, resulting from incomplete combustion of paint, coatings and oil present in dirty scrap. The smoke consists of oily carbonaceous particulate, submicron carbon and inorganic particulate, and hydrocarbons. Some hydrogen chloride (HCl) and hydrogen fluoride (HF) are present when the coating materials include PVC and Teflon.

Cover fluxes and solvent fluxes are used to remove solid impurities from the molten bath (such as dirt and various oxides) and also provide alloying agents for the molten aluminum. Cover flux initiated emissions include fumes composed of salts and oxides such as sodium chloride (NaCl), calcium chloride ($CaCl_2$), calcium fluoride (CaF_2), aluminum fluoride (AlF_3), aluminum oxide (Al_2O_3) magnesium oxide (MgO), etc. Solvent fluxes cause the formation of aluminum chloride ($AlCl_3$) vapor, which condenses to form submicron particulates.

Demagging operations, either performed by addition of aluminum fluoride or gaseous chlorine to the molten bath, are a major source of emissions. Aluminum fluoride addition results in the formation of a magnesium fluoride (MgF_2) slag and is responsible for the generation of HF (due to the hydrolysis of H_2O and F^-). Chlorine addition presents several problems: (1) free chlorine escape, (2) aluminum chloride emissions, (3) reaction of the hydroscopic $AlCl_3$ with the moisture in the air to form HCl, and (4) magnesium chloride ($MgCl_2$) emissions from the fuming dross. The demagging operation may be conducted in the charging zone, combustion zone, a third well within the reverberatory furnace or a separate holding furnace.

6.1.3 Miscellaneous Sources

In addition to the presmelting and smelting emission sources, there are a number of minor sources of air emissions throughout the secondary aluminum manufacturing process. These minor sources are all associated with the storing, sorting, loading, and transporting of scrap. During these operations fugitive dust is generated which results in some particulate emissions. These emissions are minor since the majority of the dust generated is quite large and falls to the ground immediately.

6.2 EMISSION CONTROL TECHNOLOGY

There are three basic types of pollution control systems used in the control of secondary aluminum operations. These include wet systems, dry systems, and those systems involving process adjustments. These will be described in the following subsections.

6.2.1 Wet Systems

6.2.1.1 Scrubber

The wet scrubber is very suitable for control of hygroscopic emissions from the aluminum smelter, particularly with the chlorination demagging process. Figure 6-1 outlines a process flow sketch for a wet scrubbing system with afterburner (see Section 6.2.2.3) on a furnace not employing a charging well. The spray quenching of the hot furnace gases creates steam which reacts with the $AlCl_3$ gas to form hydrated aluminum oxide (Al_2O_3) and HCl. Both of these are relatively easy to remove in an appropriately designed and operated scrubber.

For those furnaces which use a charging well, the scrubber is used in conjunction with a partially submerged collection dome, commonly known as a "bell."[9] Figure 6-2 is a sketch of such a scrubber/bell arrangement. An afterburner is also shown in this sketch. The chlorine is injected into the molten aluminum beneath the bell which collects all of the fumes and passes them on to the scrubber.

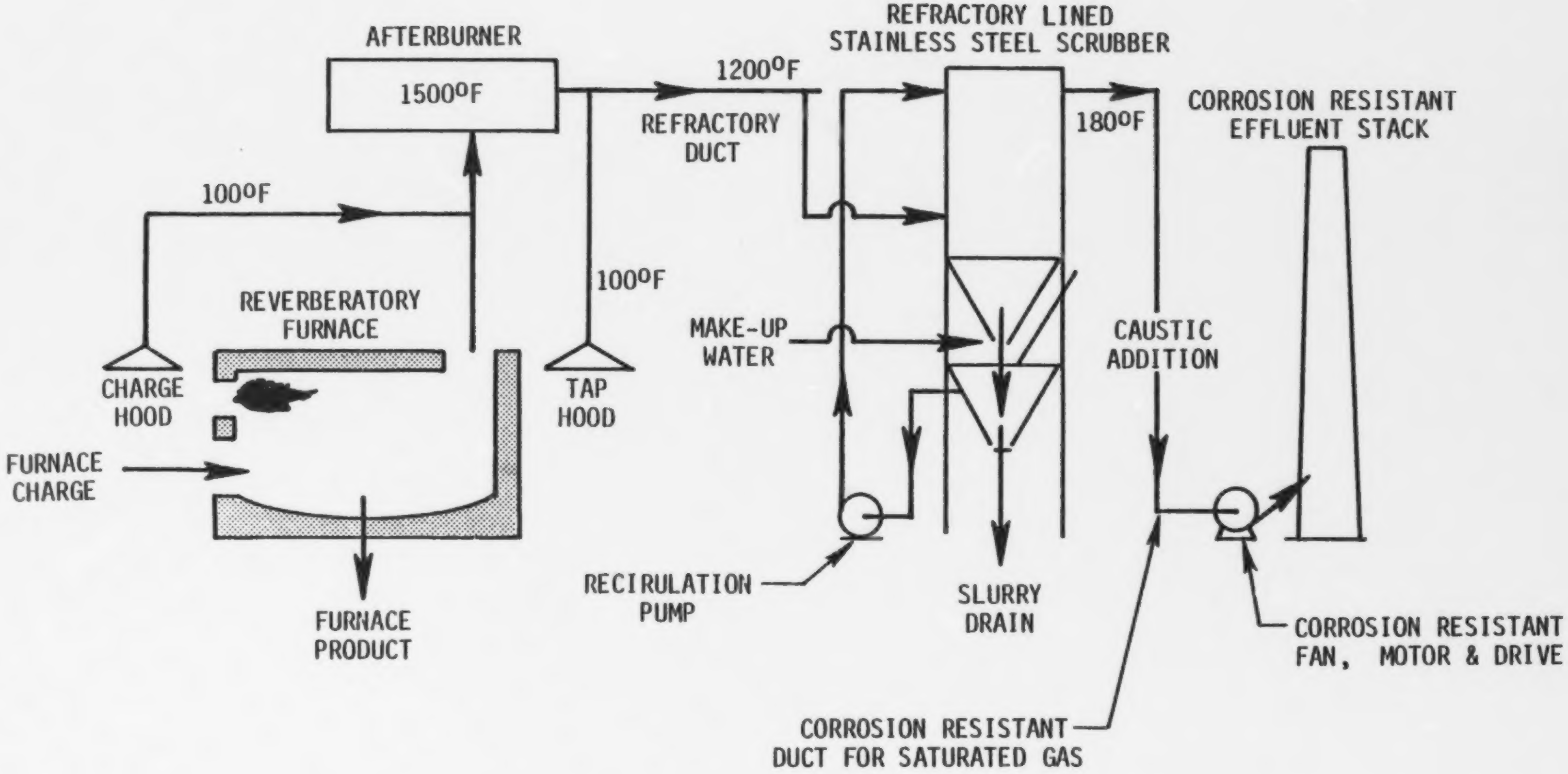

AFTERBURNER
1500°F
1200°F
REFRACTORY DUCT
REFRACTORY LINED STAINLESS STEEL SCRUBBER
180°F
CORROSION RESISTANT EFFLUENT STACK
100°F
100°F
REVERBERATORY FURNACE
CHARGE HOOD
TAP HOOD
MAKE-UP WATER
CAUSTIC ADDITION
FURNACE CHARGE
RECIRULATION PUMP
SLURRY DRAIN
FURNACE PRODUCT
CORROSION RESISTANT FAN, MOTOR & DRIVE
CORROSION RESISTANT DUCT FOR SATURATED GAS

Figure 6-1 Typical wet scrubbing installation for reverberatory furnace[4]

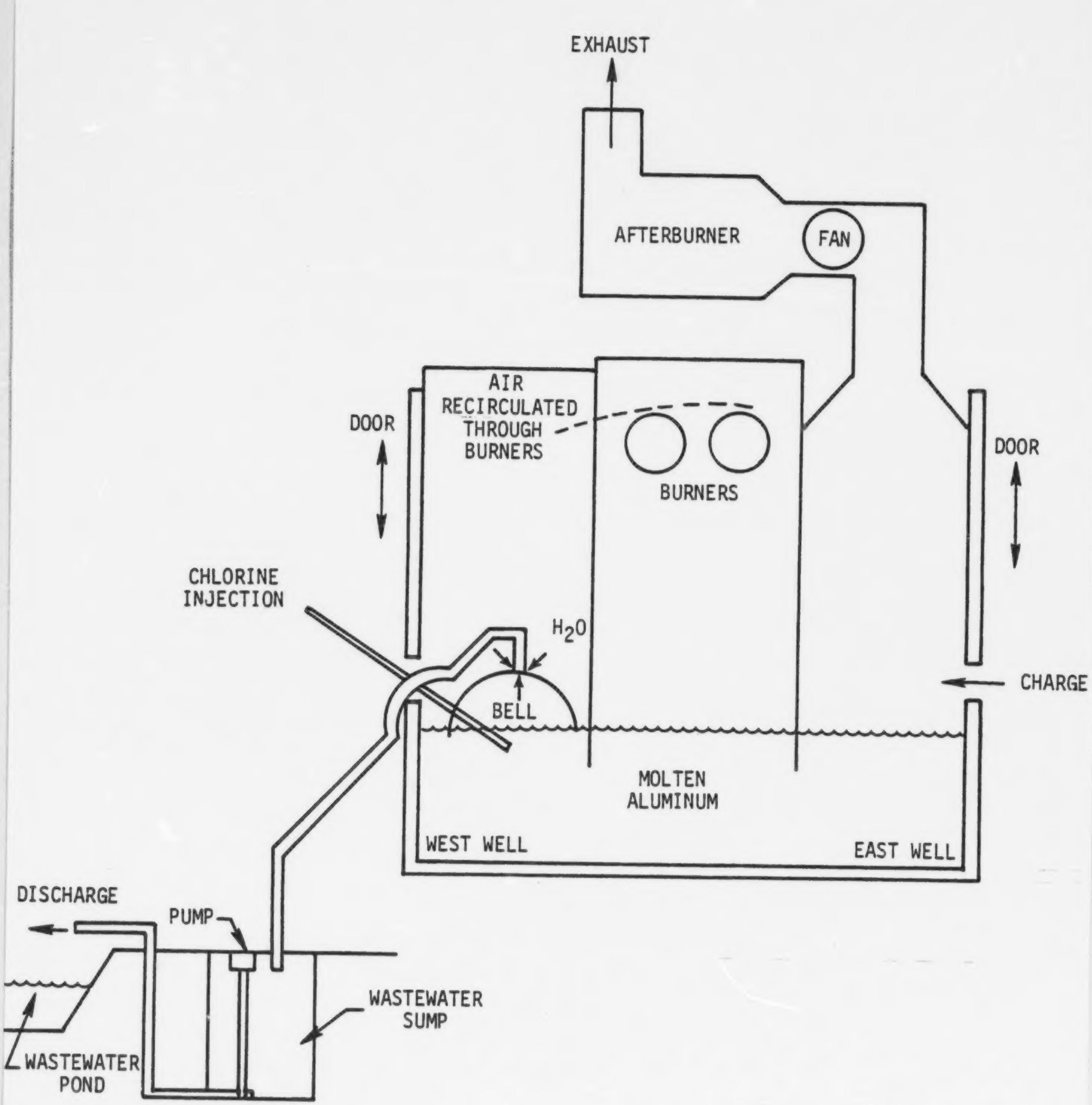

EXHAUST
AFTERBURNER
FAN
AIR RECIRCULATED THROUGH BURNERS
DOOR
DOOR
BURNERS
CHLORINE INJECTION
H_2O
BELL
CHARGE
MOLTEN ALUMINUM
WEST WELL
EAST WELL
DISCHARGE
PUMP
WASTEWATER SUMP
WASTEWATER POND

Figure 6-2 Typical scrubber installation w/afterburner on double-well furnace

In order to ottain adequate collection efficiency, the use of high-efficiency wet scrubbers, with a caustic solution as the scrubbing medium, has been found effective. Table 6-2 shows typical test data on the collection efficiency for various wet scrubbers. Scrubber collection efficiency depends mainly upon scrubbing ratio (m^3 of liquid/m^3 of gas (gal/ 1000 cu ft)), velocity of gas in the scrubber, contact time and pressure drop. The values given in Table 6-2 are typical efficiencies and do not reflect the entire range of results.

6.2.1.2 Scrubber Plus Baghouse

To more efficiently control particulate emissions from chlorinating aluminum, the wet scrubber may be followed by a baghouse or electrostatic precipitator. At present, the trend in control equipment for aluminum-fluxing emissions appears to be away from electrical precipitators and toward the scrubber-baghouse combination. More precise controls need to be developed for this technique to adapt the scrubber to the peak chlorine "burn-off" cycle when the temperature of the aluminum furnace is raised to volatilize all residual chlorine from the system.

6.2.2 Dry Systems

6.2.2.1 Conventional Baghouse

Conventional baghouses (fabric filters) are used extensively in the secondary aluminum industry for handling dust that emanates from several of the operations. Hoods are placed over loading and unloading areas, conveyors, and transfer points in order to capture the particulate emissions. The dust-laden gas stream is then cleaned via a baghouse. These systems generally operate in the 95 percent efficiency range (typically 96 percent capture efficiency and 99 percent control efficiency)[2]. Figure 6-3 shows a typical fabric filter collector installation.

Table 6-2. SCRUBBER COLLECTION EFFICIENCY FOR EMISSIONS FROM CHLORINATING ALUMINUM [1]

Contaminants	Slot Scrubber		Packed-Column Scrubber	
	Water	10% Caustic Solution	Water	10% Caustic Solution
HCl	90 to 95	95 to 99	95 to 98	99 to 100
Cl	30 to 50	50 to 60	75 to 85	90 to 95
Particulates	30 to 50	50 to 60	70 to 80	80 to 90

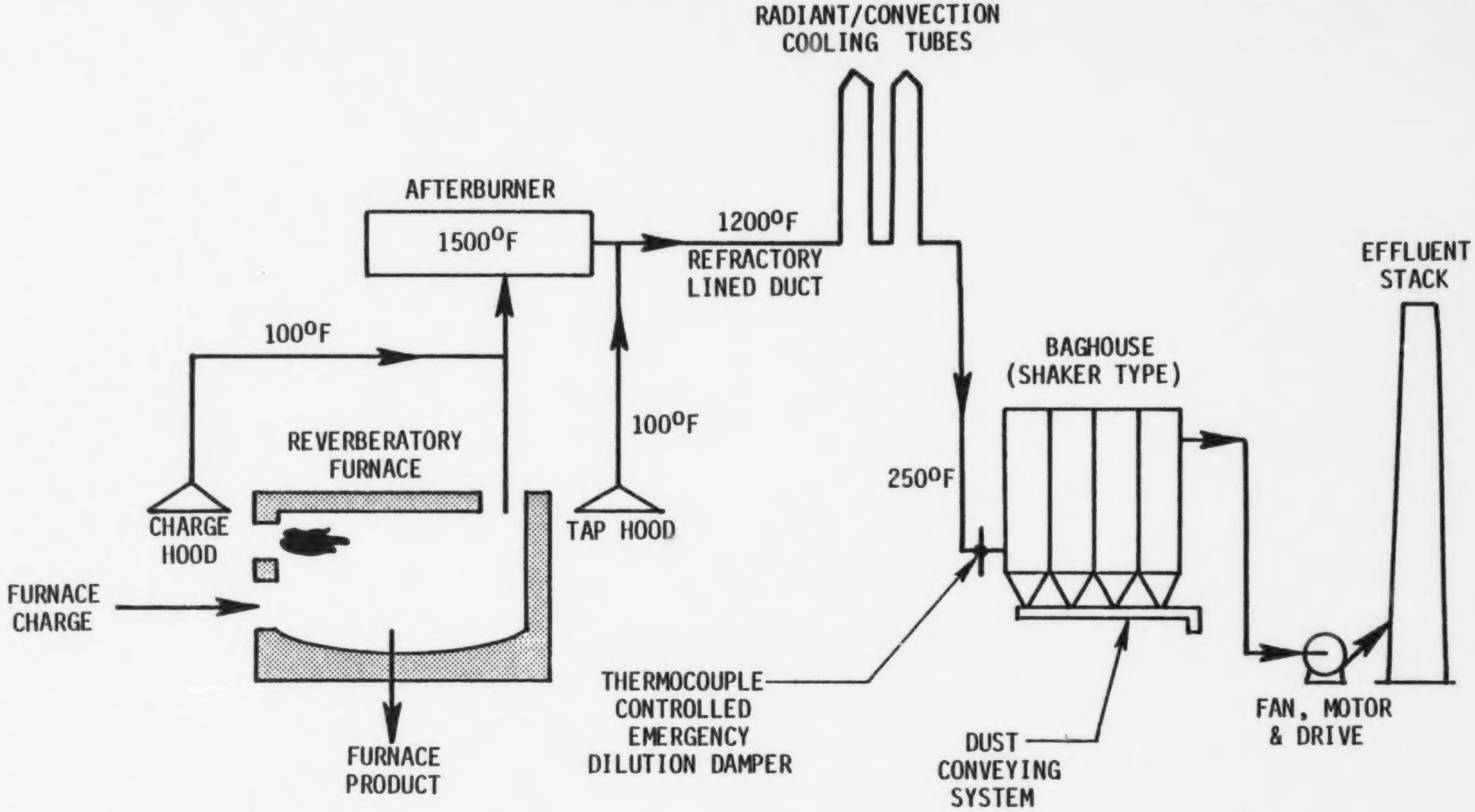

RADIANT/CONVECTION
COOLING TUBES
AFTERBURNER
1500°F
1200°F
REFRACTORY
LINED DUCT
EFFLUENT
STACK
100°F
BAGHOUSE
(SHAKER TYPE)
100°F
REVERBERATORY
FURNACE
250°F
CHARGE
HOOD
TAP HOOD
FURNACE
CHARGE
THERMOCOUPLE
CONTROLLED
EMERGENCY
DILUTION DAMPER
FAN, MOTOR
& DRIVE
DUST
CONVEYING
SYSTEM
FURNACE
PRODUCT

Figure 6-3 Typical fabric collector installation for reverberatory furnace [4]

Conventional baghouses have not been effective, however, in the removal of fumes from the demagging operations. Blinding occurs during the collection of submicron particulates. These particles enter into the interstices of the weave and create a barrier to gas flow. When blinding occurs, the pressure drop rises rapidly and gas flow diminishes. Another problem is the presence of sparks which cause bag perforation.

6.2.2.2 Coated Baghouse

A new approach for controlling pollution from secondary aluminum smelters is the use of the coated baghouse. These baghouse have been used in the primary industry for some time. The basic concept is to coat a standard baghouse with a material that absorbs and neutralizes the acid gases while simultaneously filtering out the fine particulates.

One such system is market by Teller Environmental Systems, Inc. of Worcester, Massachusetts. Their dry chromatographic system (shown in Figure 6-4) employs a chromatographic coating to protect the filter bags from both blinding and burning. The coating, called TESISORB (Patent Numbers 3721066 and 3808774), is applied batchwise to the bags through precoat inlet ducts. The quantity is approximately 96-144 kg/m^3/sec (1000-1500 lbs/SCFM) of gas flow capacity from the charging and combustion zones. Once applied, the coating is effective for several days, during which time the system may be left unattached. The primary constituents of the coating are silica (61 percent), alumina (23 percent), and soda (10 percent). Other components include potash, calcium oxide, magnesium oxide, and ferric oxide.[9]

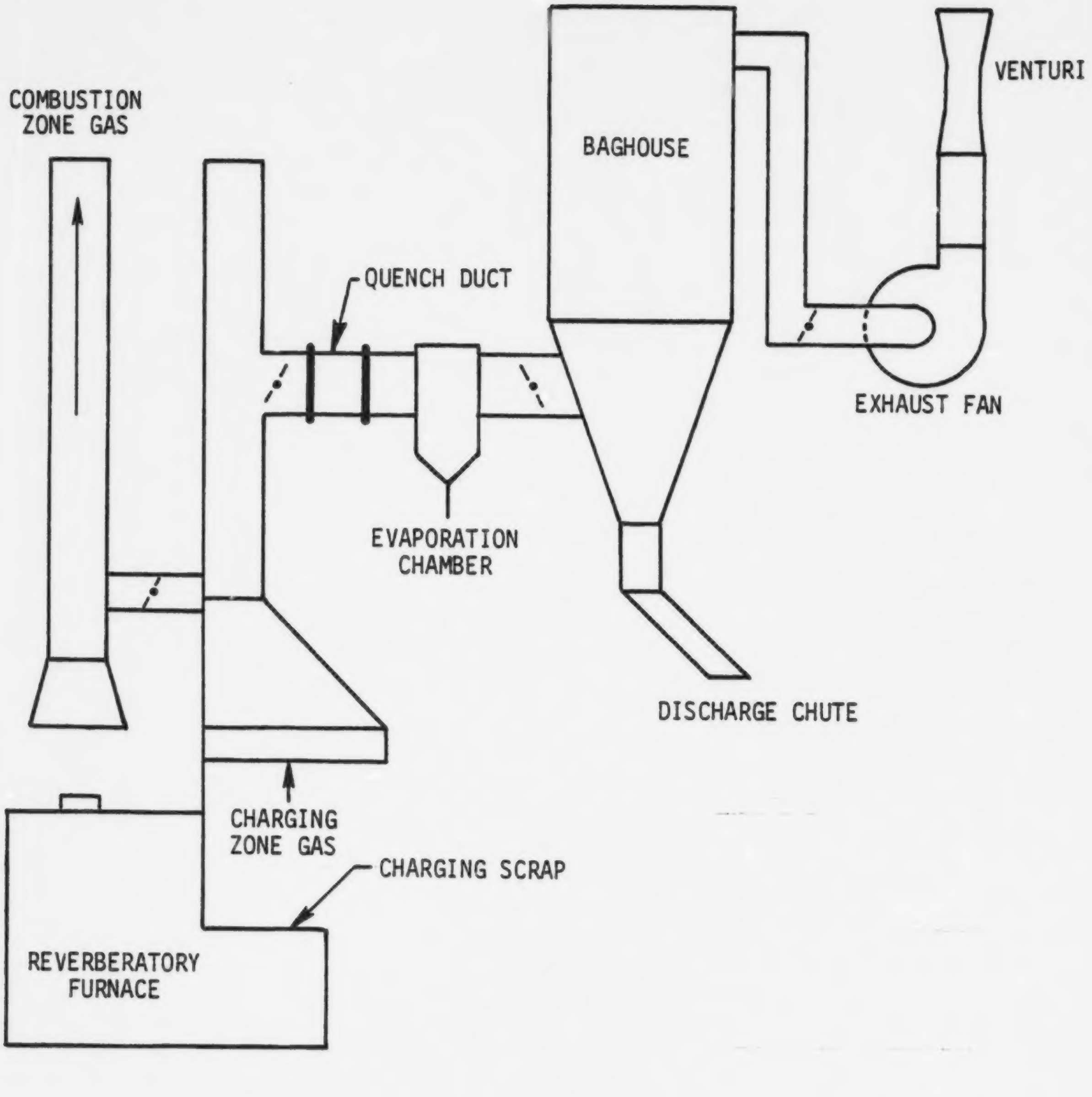

VENTURI
COMBUSTION ZONE GAS
BAGHOUSE
QUENCH DUCT
EXHAUST FAN
EVAPORATION CHAMBER
DISCHARGE CHUTE
CHARGING ZONE GAS
CHARGING SCRAP
REVERBERATORY FURNACE

Figure 6-4 Dry chromatographic system [3]

The major components of the system are the evaporation chamber, baghouse, and system blower. The system blower induces discharge gases from both the charging and combustion zone hoods into the inlet ductwork of the baghouse system. The gases are responsively cooled by water quenching and air blending to a range of 344 to 378° K (160 to 220° F) before entering the baghouse. The baghouse is shaken clean when the pressure drop reaches a preset level. This occurs every 3-5 operational days. The long shake cycle reduces mechanical wear of the bag fibers, and bag life expectancy is 5-10 years[3].

6.2.2.3 Afterburner

Afterburners are also extensively used throughout the secondary aluminum industry in order to reduce hydrocarbon emissions. Afterburners are typically used for controlling emissions from the dryers and furnaces. When afterburner temperatures are maintained at 1033 to 1144° K (1400 to 1600° F) and exhaust gas residence times are 1/2 to 1 second, essentially complete combustion will occur and there are virtually no hydrocarbon emissions. However, as in any combustion equipment where fuel is burned in the presence of air, some reaction of nitrogen with oxygen will take place to form nitric oxide and nitrogen dioxide (NO_x). Most of the NO_x formed in the afterburner is generated in the high temperature region of the burner flame. Only a minor fraction is actually produced in the main residence-time section of the afterburner.

6.2.2.4 Electrostatic Precipitators

Electrostatic precipitators (ESP's) are rarely used for pollution control in the secondary aluminum industry since they cannot remove the acid gases from the demagging operations. Another problem with ESP's is the explosion hazard inherent to their operation. Since they are infrequently used (if at all), they will not be discussed in detail in this report.

6.2.3 Process Adjustment Systems

Two systems exist for the reduction and/or removal of secondary aluminum smelting fumes without the use of conventional control equipment. These are the Derham process and the Alcoa process. Although rarely used in the industry, they are discussed in detail due to their unique nature.

6.2.3.1 Derham Process

The Derham process includes equipment and techniques for magnesium removal, with chlorine, from secondary aluminum melts with a minimum of fume generation and without major use of water in either the process or in fume control. The principal concept is the entrapment of magnesium chloride, the reaction product of magnesium removal, in a liquid flux cover, with the flux being subsequently used in the melting operations.

The elements of the Derham process consist of a separate bath of the metal to be treated with its special flux cover, and means to circulate the molten metal to and from that separate bath.

The treatment bath may be integral with the smelting furnace or separate, depending on whether the particular installation is a new facility or the equipment is being installed on existing equipment. The molten metal circulation from the main furnace hearth to the Derham unit is accomplished by pumping (usually with an air driven siphon) rather than by less direct methods, such as mechanical stirring or nitrogen gas sparging or agitation. The molten metal brought to the treatment unit is treated in the usual manner with gaseous chlorine to achieve magnesium removal, resulting in the generation of molten magnesium chloride as the reaction product. By maintaining a relatively thick cover of molten salt on the bath in the treatment unit, the emissions of aluminum chloride to the atmosphere, usually produced by demagging, are nearly completely arrested. As the flux cover becomes saturated with respect to magnesium chloride, it is removed and may be used as a flux in the main melting furnace.

Any gaseous effluents from the treatment unit are blended with the combustion gas effluent and released to the stack. Emission control requirements vary, and may be satisfied by blending the gases. In situations requiring particulate control with baghouses, the chloride emissions, although hygroscopic, are usually dilute enough not to interfere with baghouse operation.

6.2.3.2 Alcoa Process

The Aluminum Company of America is allowing the licensing of a "fumeless" demagging process, that claims achievement of 100 percent efficiency in chlorine utilization for magnesium removal. It recovers molten magnesium chloride as a product. At present, it is being used in England for captive scrap processing. The unit is installed between the holding furnace and a casting machine and removes magnesium continuously as the metal flows through.

The operation uses no flux salts and attains the high chlorine efficiencies by means of extended gas residence times provided by gas-liquid contactors. For very dirty scrap, a short period of prechlorination in the furnace is necessary to improve fluxing. The system has been operated on a commercial scale at an alloy flow rate of 98.3 kg/sec (13,000 lb/hr), with a magnesium removal rate of 0.45 kg/sec (52 lb/hr). Magnesium content was reduced from 0.5 to 0.1 percent.[10]

6.2.3.3 Use of Process Adjustment Systems

According to discussions with an outside consultant, neither of the process adjustment systems are very much in use in the secondary aluminum industry. The Derham process was developed in England and was tried by only one or two firms in the U. S. It is apparently no longer in use. The Alcoa process may be in use in a few plants, according to the consultant. The major drawback of these two processes is that they are only used for chlorine control. They are very efficient, but an additional control system is still needed to control the charging and fluxing emissions. Therefore, it is in the economic interest of the companies to install only one overall control system rather than two separate ones.

6.3 PLANTS DISPLAYING BEST SYSTEMS OF CONTROL

When discussing the "best controlled" plants, it is primarily the control of the reverberatory furnace operations (charging, demagging, and fluxing) that is being discussed since this is the area of primary emission concern. To define the "best" system of air emissions control, several parameters must be examined. These parameters are the opacity of the exhaust gases, the presence of a steam plume, control efficiency, costs, and associated water/solid waste problems. Tables 6-3 and 6-4 present a comparison of these parameters for the various control devices typically applied to a furnace.

The problem of water/solid waste disposal is one plaguing many of the industries. Scrubbers have an associated water disposal problem. At present, many states and/or cities require the wastewater discharge to be cleaned to a specified level before being sent to public treatment facilities or dumped. Federal and State water regulations have become stricter over the past few years which is forcing some plants using scrubbers to add chemical treatment plants to their facilities to clean up the discharge. In some cases, this may be economically disastrous to the plants. Baghouses have an associated solid waste disposal problem. In many cases, these wastes are carted away by a commerical contractor and used for landfill. These wastes often contain harmful fluorides which leaches back into the ground water. At present, the regulations are not strict in many areas regarding solid waste disposal. As to which is more of a problem, waste water or solid waste, is beyond the scope of this report.

Based on Tables 6-3 and 6-4, the associated discussion, and industrial contacts, it appears that the dry chromatographic baghouse is the best available control technology (BACT) for use in controlling air emissions from reverberatory furnaces. This device is really only used with fluoride demagging, although it can also be effectively used for chlorine demagging according to Teller Environmental Systems. In general, if chlorine is used for demagging, the wet scrubber with submerged dome capture system appears to be BACT. In some instances, both

Table 6-3. CONTROL SYSTEM COMPARISONS[3]

Control Device	Opacity (%)	Steam Plume	Outlet Particulate Concentration Ranges		Acid Gas Removal (%)	Comments
			g/m^3	(gr/scf)		
Electrostatic Precipitator	<10	No	.034-.046	(.015-.020)	0	Explosion hazard. Cannot remove acid gases.
Dry Chromatographic Baghouse	0	No	.077-.014	(.003-.006)	90-95	Solid waste disposal problem.
Afterburner(a) and Scrubber	>10	No	.034-.057	(.015-.025)	0	Cannot remove inorganic materials, acid gases and non-combustible carbon.
Venturi and Scrubber	<10	Yes	.034-.057	(.015-.025)	90-95	Visible steam plume. Water pollution problem.
Afterburner Scrubber	<10	Yes	.034-.057	(.015-.025)	90-95	Cannot remove inorganic material. Water pollution problem.
Baghouse	<10	No	.007-.014	(.003-.006)	0	Subject to blinding and burn-through. Cannot remove acid gases. Solid waste problem.
Baghouse and Scrubber	<10	Yes	.007-.014	(.003-.006)	90-95	Subject to bag blinding and burn-through. Water pollution problem.

NOTES: a) Emissions pulled from the charging zone hood through the combustion chamber and then through a chlorination scrubber. The combustion chamber acts as an afterburner.

Table 6-4. COMPARISON OF COSTS FOR EMISSION CONTROL SYSTEMS ON 43,360 Kg (50 TON) SECONDARY ALUMINUM FURNACES UTILIZING CL_2 FOR DEMAGGING[3]
(Costs are as of June, 1975)

	Dry Chromatographic Baghouse	Venturi and Scrubber	Afterburner and Scrubber
Capital Cost Installed(a)	$100,000	$95,000	$85,000
Operating Costs Per Year:			
1. Utilities(b)	10,000	18,000	58,000
2. Amortization(c)	10,000	9,500	8,500
3. Labor and Maintenance(d)	6,500	10,000	8,000
4. Materials and Solids Disposal(e)	4,500	5,000	5,000
Total Operating Costs:	$31,000	$42,000	$79,500
$/100 kg ($/Ton) of Aluminum (Based on 300 Day Operating Year)	2.28 (2.07)	3.12 (2.83)(f)	5.84 (5.30)(f)

NOTES:

a) Does not include furnace to system inlet ductwork, engineering, and royalties. Interior duct requirements depend on system configuration.

b) Electricity $0.02/kwh. Natural gas $0.04/$m^3$ ($1.00/1000 cu.ft.). Water $0.11/$m^3$ ($0.40/1000 gal.).

c) Straight line 10 year depreciation.

d) Labor costs $12,000/Yr/Man including overhead and fringe benefits. Maintenance (as % of total capital cost): 5% for chromatographic, 10% for venturi or turbulent contactor and chlorination scrubber, 5% for afterburner and chlorination scrubber.

e) TESISORB $42.44/1000 kg ($38.50/ton) for dry chromatographic system. Caustic $110.23/1000 kg ($100.00/ton) for wet system.

f) Not including sewerage costs.

devices are used simultaneously. There are currently four known chromatographic baghouse systems installed on secondary aluminum smelters in the United States (the original one was installed in Toronto, Canada) with one more under construction. Table 6-5 lists these best controlled plants. Table 6-6 presents some additional information regarding their baghouse systems.

Since it was not possible to contact all of the 84 plants, it is not known how many plants use the dome scrubber system. One known plant is Vulcan Materials in Sandusky, Ohio.

The two other sources of pollutants in the secondary aluminum process (the chip dryer and sweat furnace) can be best controlled using a combination afterburner and baghouse. The afterburner controls the carbonaceous emissions and a conventional baghouse controls the inorganic particulate. The sweat furnace can also be linked the dry chromatographic baghouse along with the reverberatory furnace. However, this is not always possible due to either plant layout or type of demugging.

6.4 EMISSIONS DATA

Data and information on emissions from secondary aluminum manufacturing plants were obtained from the following sources:

- Plant correspondence/visits
- Regulatory agency correspondence/visits
- Consultant correspondence
- Literature search.

This information included emission inventories, test data, design data, inspection reports, etc. Based on this information, it was possible possible to develop some emission factors for uncontrolled processes and control device efficiencies. The results are presented in the following subsections. The emission data and correspondence are presented in Appendix A.

Table 6-5. PLANTS DISPLAYING BEST CONTROL TECHNOLOGY (Dry Chromatographic Baghouse)

	Plant	Type of Demagging
1.	Rochester Smelting and Refining Co., Inc.(a) P. O. Box 547 26 Sherer Street Rochester, NY 14602	AlF_3(c)
2.	Charles Batchelder Co., Inc.(a) Swamp Road Botsford, CT 06404	Cl_2
3.	Allied Metal Co.(a) 2059 S. Canal Street Chicago, IL 60616	AlF_3
4.	Lissner Corp. (under construction)(a) 1000 N. Branch Street Chicago, IL 60622	AlF_3
5.	Apex International Alloys, Inc.(b) Chicago, IL	AlF_3
6.	Metals and Alloys(a) 195 Wicksteed Avenue Toronto, Ontario	Cl_2(c)

NOTES:
(a) Baghouse manufactured by Teller Environmental Systems, Inc.
(b) Baghouse manufactured by Wheelabrator-Fyre.
(c) Furnace emissions controlled by both scrubber and baghouse.

Table 6-6. CONTACTS FOR INFORMATION ON COATED BAGHOUSE SYSTEMS

Company	Name, Title, Phone No. of Contact
Charles Batchelder Co., Inc. Botsford, CT.	Mr. Ron Beilin Vice President (203) 426-4437
Allied Metal Co. Chicago, IL	Mr. Marvin Fink Vice President (312) 225-2800
Rochester Smelting and Refining Co., Inc. Rochester, NY	Mr. Ira Kaufmann President (716) 328-4740
Apex International Alloys, Inc. Chicago, IL	Mr. Barry Keller Vice President (312) 829-1100
Lissner Corp. Chicago, IL	Mr. Richard Lissner Vice President (312) 664-8800
Metals and Alloys Toronto, Ontario	Mr. Rudy Brandes Plant Engineer (416) 421-5771

6.4.1 Emission Factors for Uncontrolled Processes

In the secondary aluminum industry, the three main process components contributing significant airborne pollutants have been determined to be the sweat and reverberatory furnaces and the chip dryer. Uncontrolled emission rates or emission factors (EF) for the major pollutants from these processes have been determined using literature information, test report data and emission inventory numbers. Table 6-7 presents the emission factors and gives the source(s) of the information used to determine them. The actual calculations are presented in Appendix B.

The numbers presented are the best that could be determined based on the available data. It should be noted that such data are relatively scarce and more complete testing should be done in order to obtain more accurate emission estimates.

6.4.2 Control Efficiencies

The control efficiencies of those devices previously discussed as being the most widely used in the industry have been determined using literature information, test report data and emission inventory numbers. Table 6-8 presents the efficiencies and gives the source(s) of the information used to determine them. The actual calculations are presented in Appendix B.

TABLE 6-7. SECONDARY ALUMINUM PROCESS UNCONTROLLED EMISSION RATES

Process	Pollutant	Uncontrolled Emission Factor		Reference Source
Chip dryer	Particulate	7-14	kg/1000 kg alum. processed (14-28 lb/ton alum. processed)	Test data
Sweat furnace	Particulate	16.5	kg/1000 kg alum. processed (33 lb/ton alum. processed)	
Reverbatory furnace -charging	Particulate	2.2	kg/1000 kg alum. processed (4.3 lb/ton alum. processed)	5, 6, Test data
	Hydrocarbons	1.1	kg/1000 kg alum. processed (2.2 lb/ton alum. processed)	6
	Carbon monoxide		760 ppm	6
-demagging	Total Particulate	12	kg/1000 kg AlF_3 (24 lb/ton AlF_3)	6, Test data
		500	kg/1000 kg Cl_2 (1000 lb/ton Cl_2)	5
	Fluoride-particulate	4	kg/1000 kg AlF_3 (8 lb/ton AlF_3)	6, Test data
	Fluoride-gaseous	29	kg/1000 kg AlF_3 (58 lb/ton AlF_3)	6, Test data
	Chlorine-gaseous	80-300	kg/1000 kg Cl_2 (160-600 lb/ton Cl_2)	7, Test data
	Carbon monoxide		560 ppm	

TABLE 6-8. CONTROL EFFICIENCIES

Production Device	Control Device	Pollutant Controlled	Efficiency	Reference Source
Dryer Sweat Furnace	Afterburner	Particulate	90	Test data
		Hydrocarbon	99	11
		Carbon monoxide	99	11
Reverberatory furnace	Scrubber with bell system	Chlorine (Cl_2)	99.7	Test data
		Particulate	98.3	Test data
		Acid mist (HCl)	98	3
Reverberatory furnace	Coated baghouse	Particulate	98.4	6, Test data
		Gaseous fluorides	99.8	6, Test data
Dryer Sweat Furnace	Conventional baghouse	Particulate	96	2, 3
Dryer Sweat Furnace	Afterburner plus baghouse	Particulate	94	8

REFERENCES FOR SECTION 6

1. Secondary Aluminum - Melting Processes. In: Air Pollution Engineering Manual. U.S. Environmental Protection Agency. Washington, D.C. Report Number AP-40. May 1973. p. 283-292.

2. Brookman, E.T., Evaluation of Fabric Filters for Particulate Control of Industrial and Utility Boilers. The Research Corporation of New England, Wethersfield, Ct. TRC Project Number 82790. February 1978.

3. Gerstein, S.M. and M.E. Franza. Control Technology for Secondary Aluminum Smelters. Teller Environmental Systems, Inc. Worcester, MA. Report Number 75-66.6. June 1975, 14 p.

4. Hardison, L.C. and H.R. Herington. Study of Technical and Cost Information for Gas Cleaning Equipment in the Lime and Secondary Non-Ferrous Metallurgical Industries. Industrial Gas Cleaning Institute, Inc. Rye, NY. Report Number PB-198 137. December 1970. 293 p.

5. Compilation of Air Pollution Emission Factors. U.S. EPA, Research Triangle Park, NC. Report Number AP-42. February 1976. p. 7.8-1.

6. Kimura, G., W. Thorp, J. Stoklosa, G. Mackey, Stack Test Aluminum Smelting Furnace Baghouse. Engineering Services Division, Dept. of Environmental Control, City of Chicago. Report Number SS-259. September 1977. 66 p.

7. Hopper, Thomas G. and William A. Marrone. Impact of New Source Performance Standards on 1985 National Emissions From Stationary Sources. (Vol. I). The Research Corporation of New England, Wethersfield, Ct. TRC Project Number 32391. October 1975.

8. Vandegrift, A.E. and L.J. Shannon. Particulate Pollutant System Study (Vol. III - Handbook of Emission Properties.) Midwest Research Institute. MRI Project Number 3326-C. May 1971. 606 p.

9. Evaluation of a Coated Baghouse at a Secondary Aluminum Smelter. IERL. EPA Contract 68-02-1402. October 1976.

10. Train, Russell E., R. Strelow, A. C. Win, and G. S. Thompson, Jr. Development Document for Effluent Limitations Guidelines and New Source Performance Standards for the Secondary Aluminum Smelting Subcategory of the Nonferrous Metals Manufacturing Point Source Category. U. S. EPA, Washington, D. C. Report Number PB-238 464. March 1974. 131 p.

11. Bornstein, M. I. Study to Develop Background Information for the Direct Meat-Firing Industry. GCA/Technology Division, Bedford, MA. GCA Project Number GCA-TR-77-36-G. January 1978. 227 p.

7. EMISSION REGULATIONS

The following sections discuss the applicable state and local regulations regarding secondary aluminum and summarize these regulations. The values in this section are given in the units that appear in the regulations.

7.1 APPLICABLE REGULATIONS

Although secondary aluminum manufacturing is regulated under the permit and particulate regulations of the states where operations exist, few states have adopted regulations which specifically address secondary aluminum plants. Rather, states treat secondary aluminum manufacturing as a process industry for purposes of air pollution control regulations. As such, eight types of control requirements apply depending upon the particular jurisdiction:

1) General process weight limitations, typically using the following equation:

   $E = 4.10\ (P)^{0.67}$ where $P < 30$ tons/hr

   $E = [55.0\ (P)^{0.11}] - 40$ where $P \geq 30$ tons/hr

   Where

   E represents allowable emission rate (lb/hr) and P represents process weight rate (tons/hr).

2) Mass particulate emissions limitations. These are generally expressed in terms of allowable grains or pounds of particulate per standard cubic foot. Maryland and Washington use this type of limitation.

3) Control efficiency limitations. The States of Ohio and New York use this approach.

4) Control based upon the stack gas flow rate. Texas uses this type of regulation.

5) Visible emissions limitations are applicable in virtually all states studied.

6) Fugitive emissions limitations apply in most states studied.

7) Ambient and emissions limitations for fluorides apply in nine of the states covered by this study. These include: Kentucky, Louisiana, Maryland, New York, Pennsylvania, South Carolina, Tennessee, Texas and Washington.

8) A number of states have "catch-all" provisions which are intended to control toxic or hazardous emissions on a case-by-case basis.

The conclusion drawn from this analysis of state regulations is that process weight and/or fluoride emissions standards apply to secondary aluminum manufacturing in virtually all states where operations exist. The level of enforcement of these regulations is moderate and no State agency indicated that emissions from this industry was a top agency priority.

7.2 SUMMARY OF REGULATIONS APPLICABLE TO THE SECONDARY ALUMINUM MANUFACTURING INDUSTRY

Table 7-1 presents the state and local regulations as regards particulate emissions, process weights, visible emissions, fugitive emissions, fluoride standards, and any other related areas. The table presents this information for approximately 80 percent of the plants. Those states having only one or two plants were not analyzed in all cases. The figures referred to follow the table.

TABLE 7-1.

State	Particulate Matter Emission Limits	Process Weight Equation (See Key for Explanation)	Visible Emissions	Fugitive Emissions	Fluoride Standards		Other Applicable Regulations
					Ambient	Emissions	
Alabama	Chapter 4 of the Alabama Air Pollution Regulations establishes one process weight particulate standard for urbanized counties (Class I Counties) and a less stringent limit in rural counties (Class 2 Counties). New sources are subject to the same limits as apply to existing sources in Class I Counties.	Urban Counties: A Rural Counties: B	Section 4.1 limits visible emissions from stationary sources to No. 1 on the Ringlemann chart or 20% opacity. Allowance is provided for a No. 3 Ringlemann reading/60% opacity for no more than an aggregate of 3 minutes in any one hour period.	Section 4.2 requires "all reasonable precautions" to prevent fugitive emissions from the handling, storage or transport of materials. Furthermore, the discharge of visible fugitive dust emissions beyond the property line is prohibited.	Not applicable	Not applicable	None
California							
South Coast Air Quality Management District (includes Los Angeles, San Bernadino, Orange and Riverside Counties)	Rules 404 and 405 of the District regulate particulate emissions from industrial sources according to two tables. Rule 404 regulates allowable emissions as a function of stack flow rates in dry SCFM. Rule 405 requires particulate control as a function of weight.	D	Rule 401 limits visible emissions to No. 1 on the Ringlemann chart (20% capacity). This level may be exceeded for no more than 3 minutes in any one hour period.	Not applicable	Not applicable	Not applicable	None

State	Particulate Matter Emission Limits	Process Weight Equation (See Key for Explanation)	Visible Emissions	Fugitive Emissions	Fluoride Standards		Other Applicable Regulations
					Ambient	Emissions	
Bay Area Air Pollution Control District	Regulation 2 of the Bay Area District establishes both a maximum grain loading for industrial process operations of 0.15 gr/scfm and a process weight limitation. In addition, the Bay area has a total mass emission ceiling of 40 lb/hour regardless of the type or size of the source.	D	Regulation 2 establishes a visible emission limit which is the same as that of the South Coast AQM District.	Not applicable	Not applicable	Not applicable	None
Illinois	Rule 203(b) of the Illinois Stationary Source Standards establishes both a process weight equation and an accompanying graph. The most stringent of the two applies. The process weight graph is reproduced in Figure 7-1.	B (Also See Figure. 7-1)	Rule 202(b) establishes a general 30% opacity limit for existing sources with an allowance of up to 60% for an aggregate of 8 minutes in any one hour (3 times per 24 hours). The regulation provides that compliance with the process weight limits of Rule 203 is a defence to a violation of the visible emission limits of Rule 202(b).	Rule 203(b) is the Illinois fugitive particulate matter regulation. This regulation prohibits visible fugitive particulates or particulates with a mean diameter larger than 40 microns at the property line. This restriction doesn't apply to fugitive emissions from material stockpile when the wind speed is in excess of 25 mph.	Not applicable	Not applicable	None

State	Particulate Matter Emission Limits	Process Weight Equation (See Key for Explanation)	Visible Emissions	Fugitive Emissions	Fluoride Standards Ambient	Fluoride Standards Emissions	Other Applicable Regulations
Indiana	Regulation APC 5 establishes a process weight limitation which may be exceeded when the process weight exceeds 200 tons/hr provided the particulate discharge concentration is less than 0.10 lb per 1000 lb of gases at standard conditions.	B	Regulation APC 3 establishes a general 40% opacity (No. 2 Ringlemann) limit which may not be exceeded for more than a cumulative total of 15 minutes in any 24 hr period except for reasonable brief periods as specified in the operating period.	Under Indiana Regulation APC 20, fugitive dust sources are deemed in violation if any of four criteria are met: o maximum allowable particles-67% in ambient upwind concentration o 50% or more respirable dust (0.5-6 microns)-The allowable increase is reduced in proportion to the percent of respirable dust o Ambient ground level concentrations exceed 50 $\mu g/m^3$ above background for a 60-minute period. o where fugitive dust is visible crossing the property line.	Not applicable	Not applicable	None
Kentucky	401 Kentucky Administrative Regulations, Section 3:060(4) establishes Standards of Performance for process operations. This regulation allows owners to comply either with a process weight	B	In addition to the process weight and mass particulate emissions limitations of 401 KAR 3:060(4), visible particulate emissions are limited to 40% capacity.	Kentucky's fugitive emission regulation, 401 KAR 3:060(14), is virtually identical to the Alabama regulation. It requires (and enumerates) all reasonable precautions and prohibits the discharge of visible fugitive dust emissions beyond the property line.	401 KAR 3:020 (8)-Primary Standard for Gaseous Fluoride (as HF) Time-avg. (Not to be exceeded more than once/yr.) — Standard ($\mu g/m^3$) 1 month — 0.82 1 week — 1.64	Not applicable	Section 3 of 401 KAR 3:040 provides for a case by case evaluation of potentially hazardous emissions. This regulation is applicable to several of the more harmful emissions from secondary aluminum plants,

State	Particulate Matter Emission Limits	Process Weight Equation (See Key for Explanation)	Visible Emissions	Fugitive Emissions	Fluoride Standards		Other Applicable Regulations
					Ambient	Emissions	
Kentucky (cont'd)	limitation or a mass particulate emission limitation of 0.02 grains per standard cubic foot at a minimum of 97% actual removal efficiency.				24-hour 2.86 12-hour 3.68 401 KAR 3:020(9)-Primary Standards for Total Fluorides (as fluoride ion) (a) Not to exceed 40 ppm (w/w)-average concentration of monthly samples over growing season (not to exceed 6 consecutive months). (b) Not to exceed 60 ppm (w/w)-2-month average. (c) Not to exceed 80 ppm (w/w)-1-month average.		including acid mist.
Louisiana	Section 19.5 of the Louisiana Air Pollution Control Regulations establishes a general process weight standard. Under Section 19.8, the State may tighten these limits for toxic particulate emissions.	B	Section 19.5.1 establishes a general 20% opacity standard which may be exceeded for not more than 4 minutes in any consecutive 60 minutes.	Section 19.3 specifies that all reasonable precautions must be taken to prevent particulates from becoming airborne. Seven such precautions are specified, including the use of dust collectors.	Although Louisiana does not have an ambient fluoride standard, section 8.2 of the regulations prohibits emissions which will cause "undesirable levels" (i.e., harmful to humans, animals	Although there are no specific fluoride emission standards applicable to secondary aluminum manufacturing in Louisiana, sections 8.2, 9.2.1, and 17.10 prohibit emissions which would	Under sections 9.2.1 and 19.8.1, the Louisiana Air Quality Section has the authority to establish particulate emission standards for potentially toxic pollutants which are more stringent than would otherwise apply.

State	Particulate Matter Emission Limits	Process Weight Equation (See Key for Explanation)	Visible Emissions	Fugitive Emissions	Fluoride Standards		Other Applicable Regulations
					Ambient	Emissions	
Louisiana (cont'd)					plants or property) of any air pollutant. This has direct application to fluorides and acid mists emitted by secondary aluminum plants.	cause "undesirable levels" of any pollutant. The Louisiana Air Control Commission has administratively implemented this authority by establishing a 24-hr equivalent ambient fluoride standard of 1/20 T.L.V. at the property line.	
Maryland (The Baltimore Metropolitan Area)	Regulation 10.18.04.03(E) of the recently recodified Maryland Air Pollution Regulations for the Baltimore Metropolitan Area does not includea process weight limitation. Instead, a mass emission limitation of 0.03 grains/SCF is established.	Not applicable	Regulation 10.18.04.02 (A) establishes a no visible emission standard. A rather detailed variance mechanism is established whereby visible emissions are allowed on a case-by-case basis.	The Maryland fugitive emission regulations is similar to those of Alabama and Kentucky. "Reasonable precautions are specified and emissions may not traverse the property line. (Regulation 10.18.04.03(F).	Regulation 10.03.35.04I establishes statewide secondary ambient air quality standards for fluorides (including any matter containing the element fluorine in combined form) The standards are expressed	Regulations 10.03.35.04I (2) and 10.18.04.06F require fluoride emission sources to control their emissions so as not to violate the ambient standards.	Regulation 10.18.04.06 prohibits any source or operation from causing a nuisance or "air pollution.

State	Particulate Matter Emission Limits	Process Weight Equation (See Key for Explanation)	Visible Emissions	Fugitive Emissions	Fluoride Standards		Other Applicable Regulations
					Ambient	Emissions	
Maryland (cont'd)					in terms of vegetation impacts and are set forth in Figure 7-2.		
New York	Part 212, Section 212.3 of New York's Air Pollution Control Regulations establishes particulate emission limitations for existing process operations. Part 212 uses a 4-level rating system for process emissions based upon the seriousness and scope of their effects. An "A" rating indicates serious adverse effects whereas a "D" rating indicates no observable effects. Ratings of "B" or "C" are intermediate. The New York DEC applies a "B" rat- to secondary aluminum emissions. The table reproduced as Figure 7-3 contains the	C(Applicable only to solid particulates with A,B or C environmental rating)	Section 212.7 limits the opacity of emissions from process operations to 20%.	No specific regulation other than the general prohibition of "air pollution" under section 211.2.	Subpart 257-8 establishes state ambient air quality standards for fluorides. Two types of standards are established:(1) to protect against adverse effects on grazing ruminants, and (2) to protect against adverse effects on vegetation. (1) Total fluorides (ppm dry wt. basis (as F) in and on forage for consumption of grazing ruminants.	Under section 257-1.4(a) no person shall permit the emission of contaminants which alone or in combination with other sources cause contravention of the ambient standards.	Under section 257-1.4(b), notwithstanding the existence of specific standards, emissions of odorous, toxic or deleterious substance in concentrations or of such duration that will affect human health or well-being, or unreasonably interfere with the enjoyment of property or unreasonably and adversely affect plant or animal life shall not be permitted.

State	Particulate Matter Emission Limits	Process Weight Equation (See Key for Explanation)	Visible Emissions	Fugitive Emissions	Fluoride Standards		Other Applicable Regulations
					Ambient	Emissions	
New York (cont'd)	applicable particulate and gaseous emissions limitations from existing processes. Figure 7-3 is a percent efficiency table which applies to all gases and liquid particulate emissions regardless of their environmental rating and to solid particulates with ratings of either A or D. Solid particulate emissions with a B or C rating and regulated by a process weight regulation (see next column). In cases where it is impractical to apply the process weight formula to a particular B or C rated solid particulate, the regulation establishes an absolute mass				Period — Standard (ppm) Growing season (not to exceed 6 mos) — 40 Any 60-day period — 60 Any 30-day period — 80 (2) Gaseous Fluorides (as F at std. conditions) Time avg. — Standard ($\mu g/m^3$) 12 hour — 3.7 24 hour — 2.85 1 week — 1.65 1 month — 0.8		

State	Particulate Matter Emission Limits	Process Weight Equation (See Key for Explanation)	Visible Emissions	Fugitive Emissions	Fluoride Standards		Other Applicable Regulations
					Ambient	Emissions	
New York (cont'd)	limit of 0.30 lb/1000 lb of undiluted exhaust at actual conditions.						
Ohio	Regulation 3745-17-11 of the Ohio Air Pollution Control Regulations requires all industrial emissions to the more stringent of two levels: (1) a process weight limit (see next column) or (2) a percent efficiency reproduced in Figure 7-4. Figure 7-4 relates Uncontrolled Mass Rate of Emission (abscissa) to maximum allowable mass rate of emission (ordinate). The process weight limit relates process weight of materials introduced into any specific process that may cause any emission of particilate matter	B	Regulation 3745-17-07 establishes a General 20% opacity limit (No. 1 Ringlemann) for all sources. A 3 minute per hour aggregate allowance of up to 60% (No. 3 Ringlemann) is provided for.	Regulation 3745-17-08 requires and enumerates the "reasonable precautions" required to prevent particulate matter from becoming airborne.	Not applicable	Not applicable	Section 3745-15-07 is a general provision which prohibits air pollution which would unreasonably harm public health or welfare or constitute a public nuisance.

State	Particulate Matter Emission Limits	Process Weight Equation (See Key for Explanation)	Visible Emissions	Fugitive Emissions	Fluoride Standards		Other Applicable Regulations
					Ambient	Emissions	
Ohio (cont'd)	to maximum allowable mass rate of emission. The process weight limit shall apply in Priority I* regions where the Uncontrolled Mass Rate of Emission cannot be ascertained and where an emission factor characterization for the process is unknown. Curve P-1 of Figure shall apply in Priority I regions where the Process Weight Rate cannot be ascertained. In all cases, the more stringent of the two requirements shall apply where both are termed applicable.						

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*Priority I Areas are areas exceeding the National Primary Ambient Air Quality Standard for particulates.

State	Particulate Matter Emission Limits	Process Weight Equation (See Key for Explanation)	Visible Emissions	Fugitive Emissions	Fluoride Standards		Other Applicable Regulations
					Ambient	Emissions	
Pennsylvania	Section 123.13 of the Pennsylvania Air Resources Regulations regulates particulate matter emissions from process operations. For any of 30 enumerated types of processes (including secondary aluminum sweating operations). The allowable emissions are graphically illustrated in Figure 7-5. For process operations not specifically listed, allowable emissions are graphically illustrated in Figure 7-6.	See Figures 7-5 and 7-6.	Section 124.41 prohibits visible emissions, the opacity of which: 1) equals or exceeds 20% for an aggregate or more than 3 minutes in any one hour, or 2) equals or exceeds 60% at any time. This limitation does not apply to fugitive emissions which are permitted under section 123.1 (see next column).	Section 123.1(a)(9) prohibits fugitive emissions unless the Pennsylvania DER determines such emissions are of minor significance and are not preventing the attainment or maintenance of any ambient standard. Sec-123.1(c) specifies certain reasonable precautions to prevent fugitive emissions-§123.2 prohibits fugitive particulate emissions at the property line which are either visible or exceed 150 particles/cubic cm.	Chapter 131 of the Pennsylvania Regulations establishes a 24-hour fluoride standard of 5 $\mu g/m^3$ (total soluble as HF).	Under section 127.22, operating permit applications must upon request show that the source will not violate any ambient air quality standard.	Section 121.7 sets forth a general prohibition against "air pollution."
South Carolina	Regulation No. 2.6, Standard No. 5, Section VII establishes particulate emissions limitations for all unspecified process industries, including secondary	B	Regulation No. 2.6, Standard No. 1 limits smoke (i.e., small gasborne and airborne particles) emissions to No. 2 on the Ringlemann Chart. Special limited allowance of up to No. 3 on the chart are provided for startup, shut down, soot blowing and equipment charge.	None (Revised SIP will address this)	Standard 3 of Regulation 2.6 establishes a gaseous fluoride ambient standard of 0.3 $\mu gm/cm^2/mo$. measured as HF over a 30-day interval.	Although South Carolina does not have any specific fluoride emissions standards, the air pollution control agency does model significant fluoride emissions	Under Regulation No. 2.5 sources must take all steps necessary to prevent air emissions which could injure human health and welfare, including possible injury to plant

State	Particulate Matter Emission Limits	Process Weight Equation (See Key for Explanation)	Visible Emissions	Fugitive Emissions	Fluoride Standards		Other Applicable Regulations
					Ambient	Emissions	
South Carolina (cont'd)	aluminum manufacturing. South Carolina uses an environmental effects factor similar in concept to New York's environmental rating system. To date, however, only sulfuric acid mists are given special (more stringent) treatment under the regulations.					sources on a case by case basis to assure the integrity of the ambient fluoride standard.	or animal life or property.
Tennessee	Chapter 1200-3-7 sets forth the process Emission Standards for the State of Tennessee. That Chapter allows operators to select between the diffusion equation set forth in Figure 7-7 or a type B process weight limitation (see key). Whichever standard is chosen, all sources at the same facility must be	B	Under section .01 of Chapter 1200-5-5, no person shall discharge visible emissions from any air contaminant source with a density greater than number one (1) of the Ringelmann Chart or an opacity in excess of twenty (20) percent for an aggregate of more than five (5) minutes in any one (1) hour or more than twenty (2) minutes in any twenty-four (24) hour period.	In addition to establishing typical "reasonable precautions" for controlling fugitive emissions from the transport, handling or storage of materials, Chapter 1200-3-8 prohibits fugitive dust to be emitted in such manner to exceed five (5) minutes per hour or twenty (20) minutes per day as to produce a visible emission beyond the property line of the property on which the emission originates, excluding malfunction of equipment.	See Figure 7-8.	Chapter 1200-3-1 as well as section 1200-3-9-.02 (4) existing sources must not cause violations of the ambient standards.	Under Section 1200-3-7.07 all gaseous emission sources must install and use reasonably available controls.

State	Particulate Matter Emission Limits	Process Weight Equation (See Key for Explanation)	Visible Emissions	Fugitive Emissions	Fluoride Standards		Other Applicable Regulations
					Ambient	Emissions	
Tennessee (cont'd)	regulated by that standard. In counties where the ambient particulate standard is being exceeded, the Tennessee Air Pollution Control Board has the responsibility for establishing emission limitations which are as stringent as necessary to attain the standard, regardless of the abovementioned regulation.						
Texas	Rule 105 of Texas Regulation I establishes particulate matter emissions limitations for sources other than those processing or handling agricultural commodities. Sources subject to Rule 105 must conform to the allowable emission rates as shown in Figure	Not applicable	Rule 103 of Texas Regulation I prohibits excessive visible emissions from any enclosed building or facility. With respect to stack emissions, the rule specifies a 30% opacity limit, averaged over a 5-minute period. Stacks constructed after January 31, 1972, are limited to 20% opacity on a 5-minute average.	Rule 104 of Texas Regulation I establishes and enumerates "reasonable precautions" which must be adopted to prevent particulates from becoming airborne in areas which are nonattainment for the ambient particulate standard.	See Figure 7-11.	See Figure 7-11.	Rule 5 is a general nuisance statute applicable to air pollution.

State	Particulate Matter Emission Limits	Process Weight Equation (See Key for Explanation)	Visible Emissions	Fugitive Emissions	Fluoride Standards: Ambient	Fluoride Standards: Emissions	Other Applicable Regulations
Texas (cont'd)	7-9 and/or Figure 7-10. Each regulates emissions according to the effluent flow rate of the source adjusted for stack height. In addition, Rule 105 establishes an ambient air quality-related emission standard which prohibits particulate emissions which would cause any of the time-averaged not ground level particulate concentrations to be exceeded: Time Avg. (hrs) — Concentration ($\mu g/m^3$) 5 — 100 3 — 200 1 — 400						
Washington	Chapter 173-400, Section 060 of the Washington Administrative Code establishes a minimum particulate emission standard of 0.10 grains per std.	Not applicable	Chapter 173-400, Section 040(1) of the Washington Code establishes a general 3-minute/hr 20% opacity standard which may not be exceeded for more than 15 minutes in any consecutive 8 hours.	Chapter 173-400, Section 040(3) and 040(8) specify reasonable precautions to prevent fugitive releases in connection with the handling, transporting and storing of particulate material.	Two standards are established by these rules. One shall be for the fluoride content of forage and the other for gaseous fluorides in the ambient air.	WAC section 18-48-010 requires all fluoride emission sources to apply "highest and best practicable controls" unless the	None

State	Particulate Matter Emission Limits	Process Weight Equation (See Key for Explanation)	Visible Emissions	Fugitive Emissions	Fluoride Standards		Other Applicable Regulations
					Ambient	Emissions	
Washington (cont'd)	cubic ft. of dry exhaust gas for general process sources. No process weight limitation is established under Washington's air pollution control regulations.			No specific precautionary measures are specified.	Forage Standards (a)Forty parts per million fluoride ion (40 ppm F) average for any twelve (12) consecutive months. (b)Sixty parts per million fluoride ion (60 ppm F) each month for more than two (2) consecutive months. (c)Eighty parts per million fluoride ion (80 ppm F) more than once in any two (2) consecutive months. (2)in areas where cattle are not grazed continually, but are fed cured forage part of the year, the fluoride content of the cured forage shall be used as the forage fluoride content for as many months as it is fed to establish the yearly average.	applicant shows that lesser technology is required. Further, no person shall allow any emission of elemental or chemically combined fluorine, which either alone or in combination with other fluorides that may be present in forage or the ambient air, to be in ex--cess of the standards.	

State	Particulate Matter Emission Limits	Process Weight Equation (See Key for Explanation)	Visible Emissions	Fugitive Emissions	Fluoride Standards		Other Applicable Regulations
					Ambient	Emissions	
Washington (cont'd)					(3)Cured forage grown for sale in livestock feed shall not exceed forty parts per million fluoride ion (40 ppm F) by dry weight after curing or preparing for sale. Ambient Air Standards (HF) Gaseous fluorides in the ambient air calculated as HF at standard conditions shall not exceed: (1)Three and seven tenths micrograms per cubic meter (3.7 micrograms per cubic meter) average for any twelve (12) consecutive hours; (2)Two and nine-tenths micrograms per cubic meter (2.9 micrograms per cubic meter) average for any twenty-four (24) consecutive hours; (3)One and seven-tenths micrograms per cubic meter (1.7 micrograms per cubic meter) average for		

State	Particulate Matter Emission Limits	Process Weight Equation (See Key for Explanation)	Visible Emissions	Fugitive Emissions	Fluoride Standards		Other Applicable Regulations
					Ambient	Emissions	
Washington (cont'd)					any seven (7) consecutive days. (4)Eighty-four one hundredths micrograms per cubic meter (0.84 micrograms per cubic meter) average for any thirty (30) consecutive days; (5)Five-tenths micrograms per cubic meter (0.5 micrograms per cubic meter) average for the period March 1 through October el of any year.		

Key: Process Weight Equations

(A) $E = 3.59\ (P)^{0.62}\ (P < 30\ \text{tons/hr})$

$E = 17.31\ (P)^{0.62}\ (P \geq 30\ \text{tons/hr})$

(B) $E = 4.10\ (P)^{0.67}\ (P < \text{tons/hr})$

$E = [55.0\ (P)^{0.11}] - 40.0\ (P \geq 30\ \text{tons/hr})$

(C) $E = 0.024\ (P)^{0.665}\ (P \leq 50\ \text{tons/hr})$

$E = [39\ (P)^{0.082}] - 50\ (P > 50\ \text{tons/hr})$

(D) $E = 4.10\ (P)^{0.67}$ (Regardless of P Value)

Where:

E = allowable emission rate in pounds per hour, and
P = process weight rate in tons per hour.

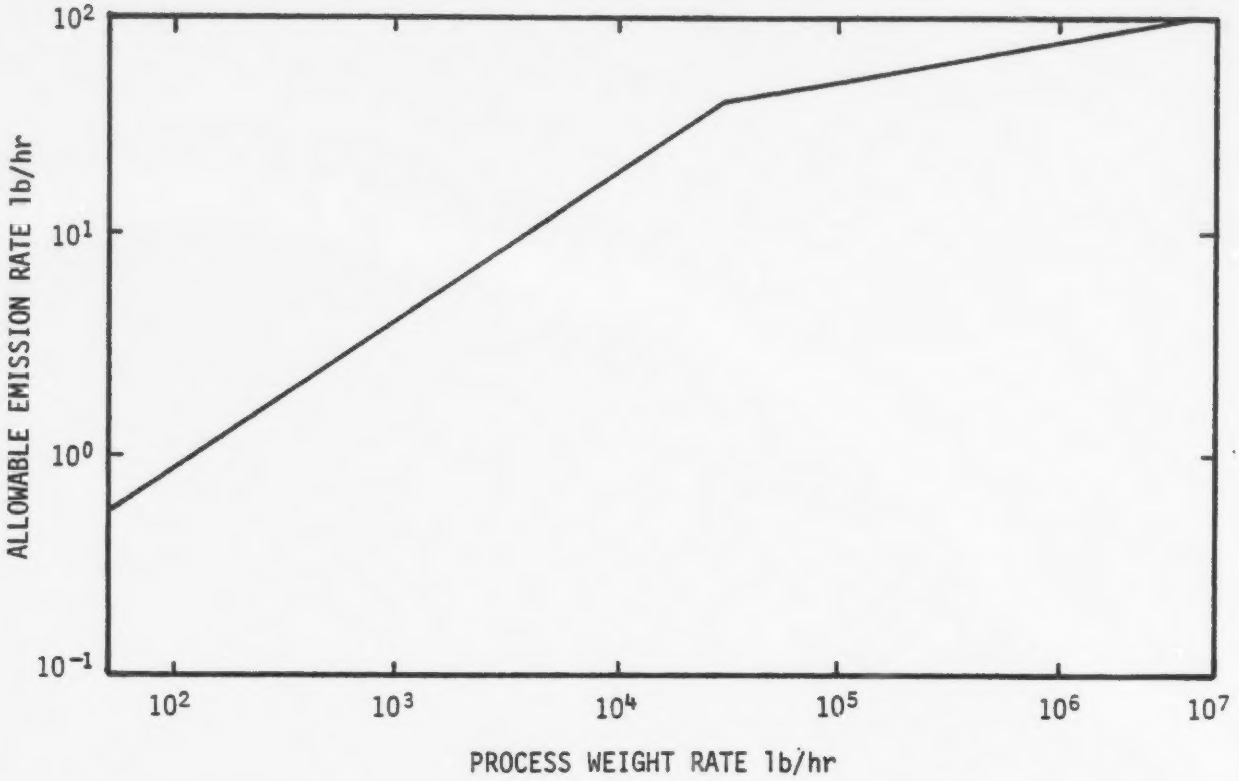


Figure 7-1. Illinois process weight curve

Ambient air quality standards for fluorides at the more adverse and serious level shall be those concentrations in the ambient air qhich result in the following values being exceeded.

a. Vegetable Crops. Vegetable tissue intended for human use, trimmed as normally marketed or consumed shall not exceed 20 micrograms F per gram dry tissue in unwashed samples.

b. Field Crops.

(1) Middle aged fully expanded leaves of corn or sorghum intended for grain shall not exceed, at time of tasseling, 35 micrograms F per gram dry tissue in washed samples.

(2) Any field crops intended for market as hay, silage or forage shall not exceed 40 micrograms F per gram dry tissue in unwashed samples as marketed.

(3) Other field crops at any stage of growth shall not exceed 50 micrograms F per gram dry tissue in washed samples.

c. Cattle Forage.

(1) Running averages of 12 monthly samples of forage or hay or silage grown in the area as feed shall not exceed 40 micrograms F per gram tissue in unwashed samples.

(2) The average of any 2 consecutive months samples of forage or hay or silage grown in the area as feed shall not exceed 60 micrograms F per gram dry tissue in unwashed samples.

(3) No monthly sample of forage or hay or silage grown in the area as feed shall exceed 80 micrograms F per gram dry tissue in unwashed samples.

d. Fruit Trees, Berries, and Other Commercial Crops. Fully expanded functional leaves shall not exceed 50 micrograms F per gram dry tissue in washed samples.

e. Deciduous Trees and Shrubs. Fully expanded functional leaves shall not exceed 100 micrograms F per gram dry tissue in washed samples.

f. Conifers and Evergreen Trees or Shrubs. Fully expanded leaves or needles of the current year shall not exceed 50 micrograms F per gram dry tissue in washed samples. Leaves and needles of prior season shall not exceed 75 micrograms F per gram dry tissue in washed samples.

g. Grasses and Herbs. Grases and herbs not subject to browsing, grazing, or harvest for use in feeds or food shall not exceed 150 micrograms F per gram dry tissue in washed samples.

h. Ornamental Plantings. Ornamental plants, except trees, shrubs and turf where §D, E, F, and G above apply, shall not exceed 40 micrograms F per gram dry tissue in fully expanded leaves in washed samples, at any period during the growing season.

i. Other Values. If it considers vegetation sampling to be not practicable, the Department may assume unsatisfactory conditions when either:

(1) Static limed filter paper samples of 28 to 32 days exposure exceed 5 micrograms F per 100 square centimeters per day or,

(2) Gaseous fluorides exceed 2 micrograms F per cubicmeter of air in any 24 hour sample and any 72 hour average exceeds 0.4 micrograms F per cubic meter of air.

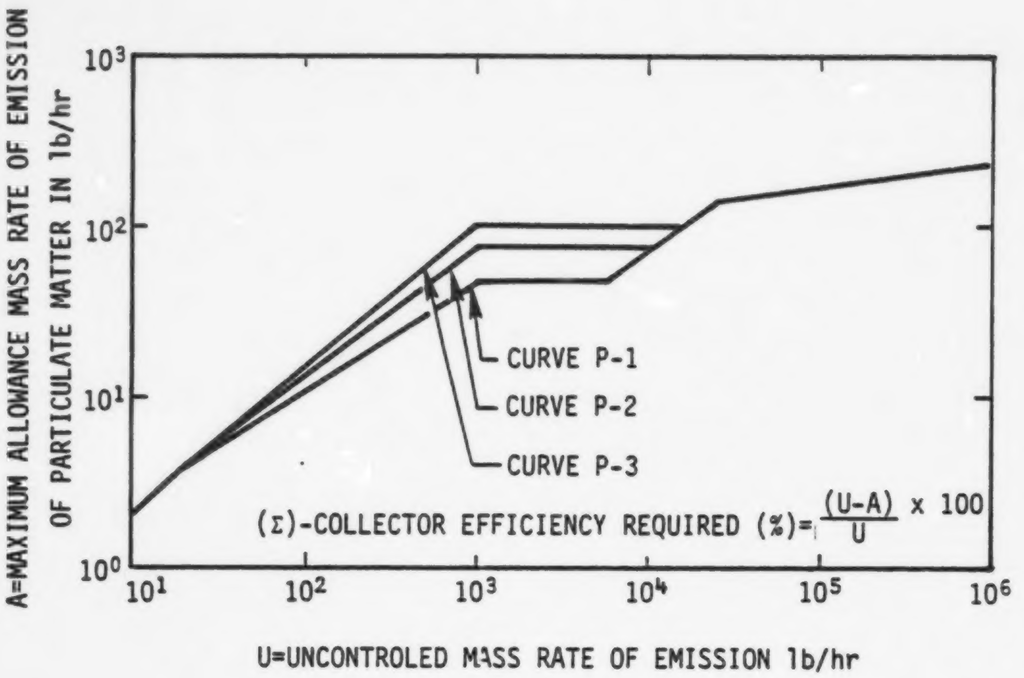
Figure 7-2. Maryland Secondary Ambient Fluoride Standards.

			EMISSION RATE POTENTIAL (LB/HR)							
Environmental Rating	Less than 1.0	1 to 10	10 to 20	20 to 100	100 to 500	500 to 1,000	1,000 to 1,500	1,500 to 4,000	4,000 to 10,000	10,000 to Greater
A	*	99% OR GREATER								
B	*		90-91%	91-94%	94-96%	96%-97%		97-98%	98-99%	99% or Greater
C	*		70-75%	75-85%	85-90%	90-93%		93-95%	95-98%	98% or Greater
D	*									

*Degree of air cleaning required shall be specified by the Commissioner.

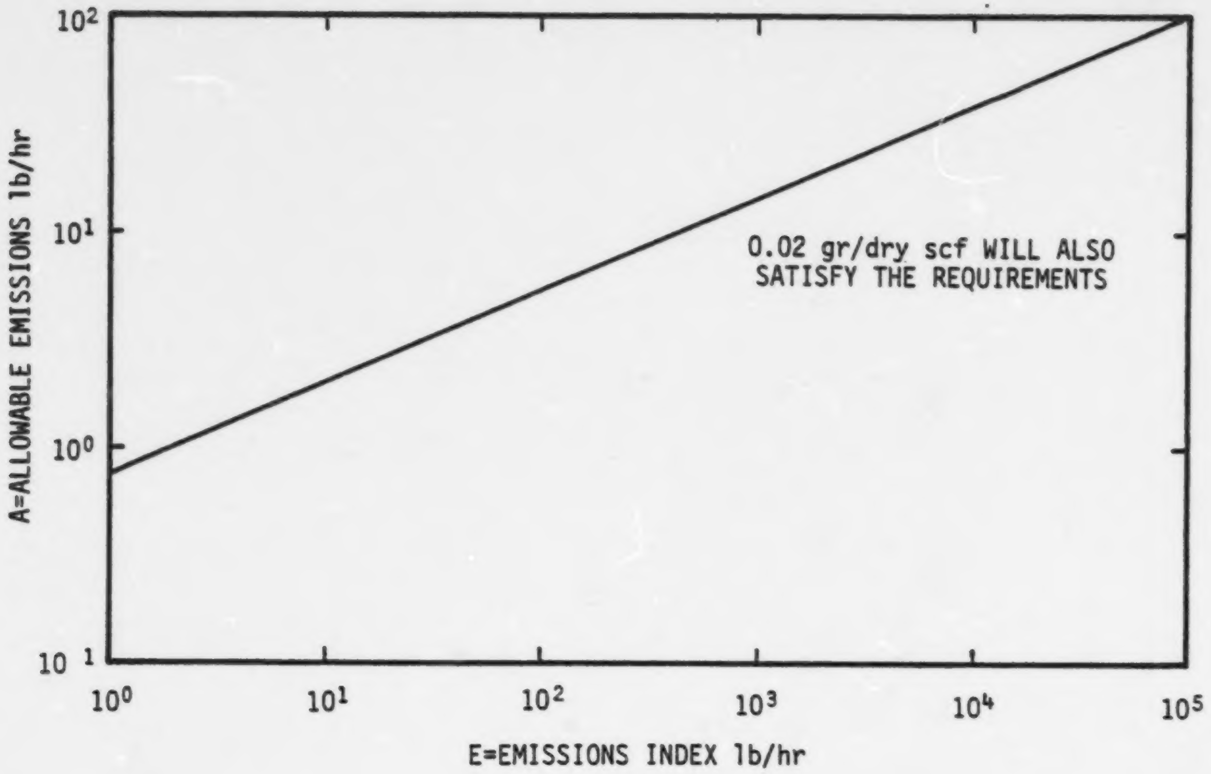
NOTE: Solid particulates with an environmental rating of either B or C are governed by the process weight limitation described in the text. Most solid particulates emitted by secondary aluminum plants have a B rating.

Figure 7-3. New York Percent Efficiency Table.



NOTE: AFTER JULY 1, 1975, CURVE P-1 APPLIES IN ALL CASES WHERE THIS REQUIREMENT IS DEEMED APPLICABLE.

Figure 7-4. Ohio collector efficiency curve

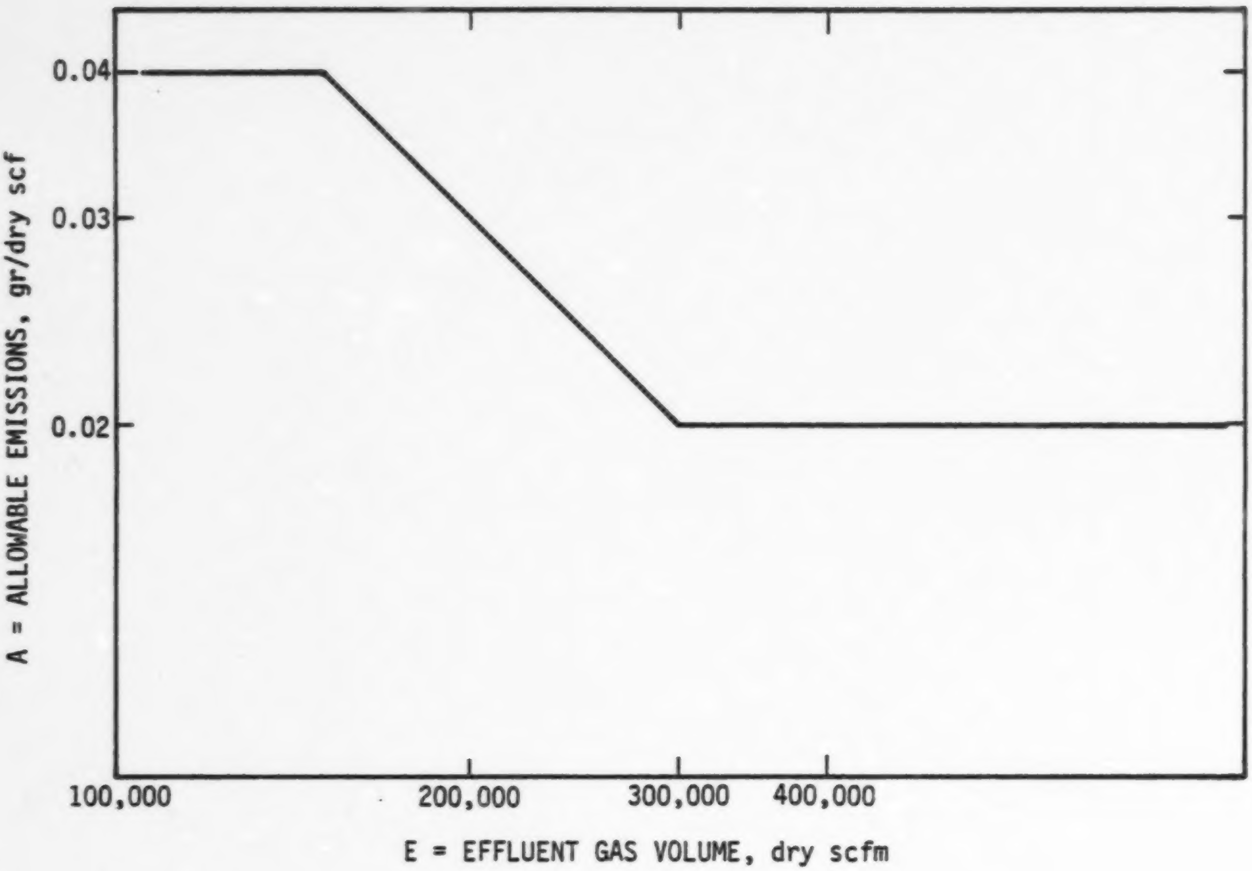


FORMULA

$A=0.76E^{0.42}$ WHERE:
A=ALLOWABLE EMISSIONS IN lb/hr
E=EMISSIONS INDEX=F x W lb/hr
F=PROCESS FACTOR IN lb/unit AND
W=PRODUCTION OR CHARGING RATE IN unit/hr

THE FACTOR F FOR MELTING AND REFINING OPERATIONS IN SECONDARY ALUMINUM PLANTS IS 10lbs/ton OF ALUMINUM FEED. THE FACTOR F FOR SECONDARY ALUMINUM SWEATING OPERATIONS IS 50lbs/ton OF ALUMINUM PRODUCT.

Figure 7-5. Pennsylvania allowable emissions curve for sources specifically listed under Section 123,13 (includes sweating and melting/refining operations in secondary aluminum production plants)



THIS GRAPH TRANSLATES AS FOLLOWS:

(i) 0.04 GRAINS PER DRY STANDARD CUBIC FOOT, WHEN THE EFFLUENT GAS VOLUME IS LESS THAN 150,000 DRY STANDARD CUBIC FEET PER MINUTE.
(ii) THE RATE DETERMINED BY THE FORMULA:
$A = 6000E^{-1}$, WHERE:

A = ALLOWABLE EMISSIONS IN GRAINS PER DRY STANDARD CUBIC FOOT, AND
E = EFFLUENT GAS VOLUME IN DRY STANDARD PER CUBIC FEET PER MINUTE,
WHEN E IS EQUAL TO OR GREATER THAN 150,000 BUT LESS THAN 300,000.
(iii) 0.02 GRAINS PER DRY STANDARD CUBIC FOOT, WHEN THE EFFLUENT GAS VOLUME IS GREATER THAN 300,000 DRY STANDARD CUBIC FEET PER MINUTE.

Figure 7-6. Pennsylvania allowable emissions curve for sources not listed in Section 123.13

(a) Stack gas exit temperature less than 100 degree F. (See Note).

$$Q = 3.02 \times 10^{-4} V_s h_s^2 \quad {\frac{d_s}{h_s}}^{0.71}$$

(b) Stack gas exit temperatur of 125 degrees F or greater (see Note).

1. Stacks less than 500 feet in height

$$Q = 0.2h_s(Q_T \times 0.02 \times (T_s - 60))^{0.25}$$

2. Stacks 500 feet in height and greater

$$Q = 0.3h_s(Q_T \times 0.02 \times (T_s - 60))^{0.25}$$

(c) 1. For stack gas exit temperatures from 100 degrees F to 124 degrees F calculate allowable emissions as in (a) and either (b)1, or (b)2, depending upon stack height (using T_s of 120°F) and make linear interpolation based upon actual stack gas exit temperature.

2. The terms of the preceding equations shall have the following meaning and units:

(i) d_s - inside diameter or equivalent diameter or stack tip in feet.

(ii) h_s - stack height in feet (vertical distance above grade directly below tip of stack).

(iii) Q - maximum allowable emission rate in pounds per hour.

(iv) Q_T - volume rate of stack gas flow in cubic feet per second calculated to 60°F.

(v) T_s - temperature of stack gases at stack tip in °F.

(vi) V_s - velocity of stack gases at stack tip in feet per second.

(vii) NOTE: In determining applicability of equations in this paragraph based upon exit gas temperature the actual exit gas temperature must equal or exceed the stated temperature during ninety (90) percent or more of the operating time.

NOTE: Owners or operates of process emission sources may elect to have their process emissions regulated by the Process Weight Table, described in the text.

Figure 7-7. Tennessee Particulate Diffusion Equation for Process Sources.

Primary Standards			Secondary Standards		
Concentration		Averaging Interval	Concentration		Averaging Interval
$\mu g/m^3$	ppb by vol.		$\mu g/m^3$	ppb by vol.	
1.2	1.5	30 days	1.2	1.5	30 days
1.6	2.0	7 days	1.6	2.0	7 days
2.9	3.5	24 hrs.	2.9	3.5	24 hrs.
2.7	4.5	12 hrs.	3.7	4.5	12 hrs.

NOTES:
1. All values are maximum not to be exceeded more than once per year.
2. Concentrations in micrograms per cubic meter ($\mu g/m^3$) are approximately only.
3. All conditions relate to air at standard conditions of 25°C temperature and 760 millimeters of mercury pressure.
4. All averaging intervals are consecutive time periods.

Figure 7-8. Tennessee Ambient Air Quality Standards for Gaseous Fluorides Expressed as HF.

Effluent Flow Rate acfm	Rate of Emission lb/hr
1,000	3.5
2,000	5.3
4,000	8.2
6,000	10.6
8,000	12.6
10,000	14.5
20,000	22.3
40,000	34.2
60,000	44.0
80,000	52.6
100,000	60.4
200,000	92.9
400,000	143.0
600,000	184.0
800,000	219.4
1,000,000	252.0

Interpolation and extrapolation of the data in this table shall be accomplished by the use of the equation $E = 0.048\ q^{0.62}$ where E is the allowable emission rate in lb/hr and q is the stack effluent flow rate in acfm.

Figure 7-9. Texas Allowable Particulate Emission Rates for Specific Flow Rates.

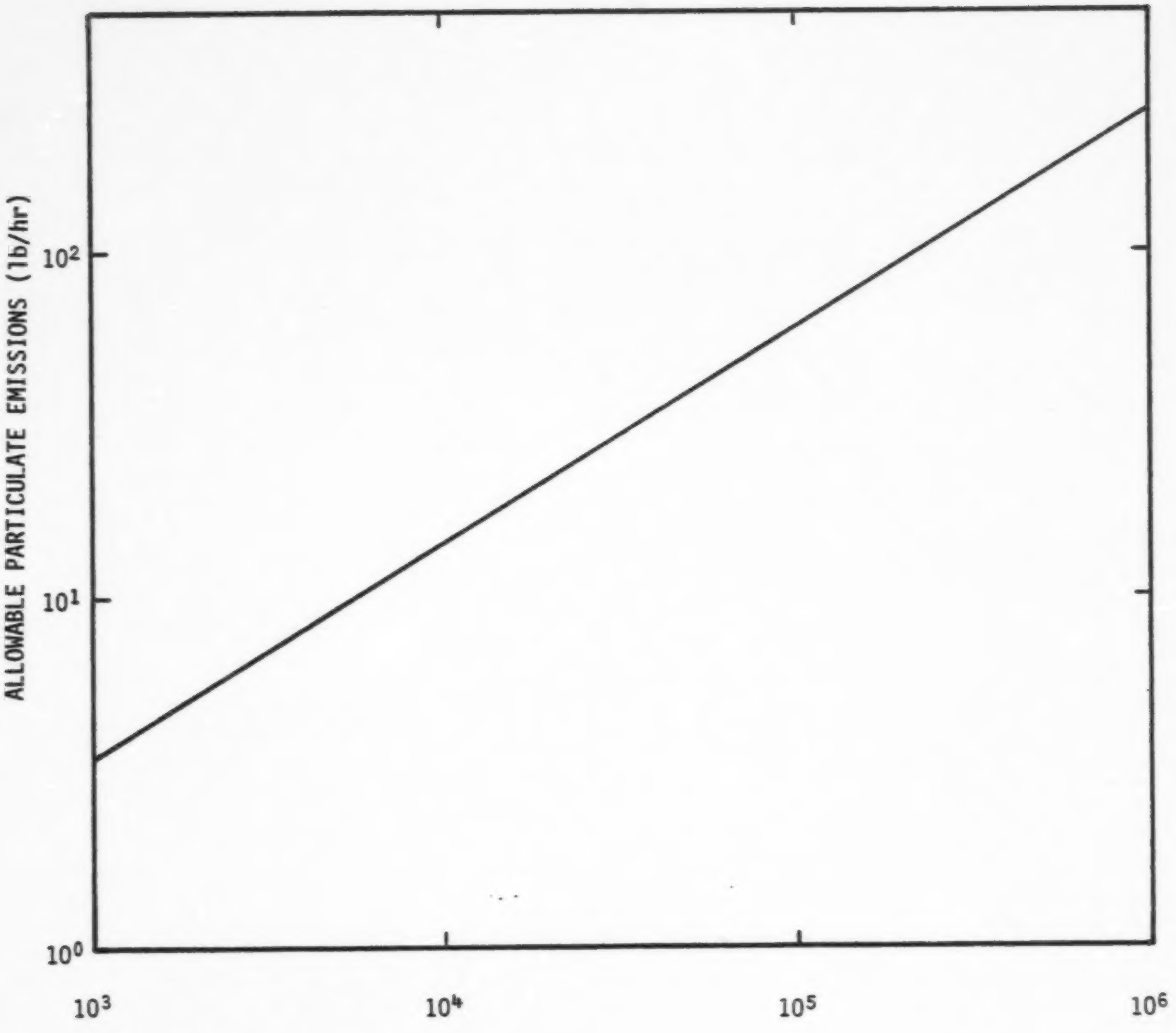


FIGURE 7-10. Texas allowable particulate emission rates for specific flow rates

a. The Board declares that concentrations of gaseous inorganic fluoride compounds in the atmosphere, calculated as HF, in excess of:

4.5 ppb for any 12-hour period
3.5 ppb for any 24-hour period
2.0 ppb for any 7-day period
1.0 ppb for any 30-day period

by volume at 760 mm Hg and 25 degrees C average constitute undesirable levels, whether the sources are from natural causes or from the activities of man, and that a state of air pollution exists when concentrations of any gaseous inorganic fluoride compound, calculated as HF, exceed any of these levels.

b. The Board further declares that concentrations of inorganic fluoride compounds in forage located in a Type D land use area, including inorganic fluoride compounds both absorbed in and deposited on forage, calculated as fluoride ion, in excess of any of the following levels indicate the presence of undesirable levels in the area in which the forage is grown, whether the sources are from natural causes or from the activities of man; and that a state of air pollution exists when concentrations of inorganic fluoride compounds, calculated as fluoride ion, exceed any of the specified levels:

(1) An average of 40 parts per million by weight based on samples taken once a month over a period of 12 consecutive calendar months; or

(2) An average of 60 parts per million by weight based on samples taken once a month over a period of three consecutive calendar months; or

(3) An average of 80 parts per million by weight based on samples taken once a month over a period of two consecutive calendar months.

To assist in meeting the ambient air quality standards, the Board hereby establishes a limit on the emission of gaseous inorganic fluoride compounds, calculated as HF, which may be made from any property not to exceed 6 parts per billion by volume average during a period of 3 consecutive hours. The contribution of inorganic fluoride compounds by a single property shall be measured by the difference between the upwind level and the downwind level of inorganic fluoride compounds for the property, or by stack sampling calculated to a downwind concentration.

The maximum allowable fluoride emission rate which may be made from a stack on a property to comply with the emission limit set forth in this Regulation may be calculated by Sutton's Equation which has been modified to consider the critical wind speed and to correspond to a 3-hour air sample. The equations used for fluoride for cold and hot stacks are:

1. For exit stack gas for temperatures of less than 125 degrees F.

(a) All land use types

$$Qa = 5.8 \times 10^{-5} V_s d_s^2 \qquad \frac{1}{\left[\frac{d_s}{h_s}\right]^{1.29}}$$

Where:

Qa = emission rate lbs/hr.
V_s = stack exit velocity, ft/sec.
d_s = exit stack diameter, ft.
h_s = physical stack height, ft.

(See Graph 1.)

2. For exit stack gas for temperatures greater than 125 degrees F.

(a) All land types

$$Qa = 1.28 \times 10^{-4} V_s d_s \quad \left[1.5 + 0.82\left(\frac{\Delta T}{T_s}\right) d_s \qquad h_s\right]$$

Where:

Qa = emission rate, lbs/hr.
V_s = stack exit velocity, ft/sec.
d_s = exit stack diameter, ft.
h_s = physical stack height, ft.

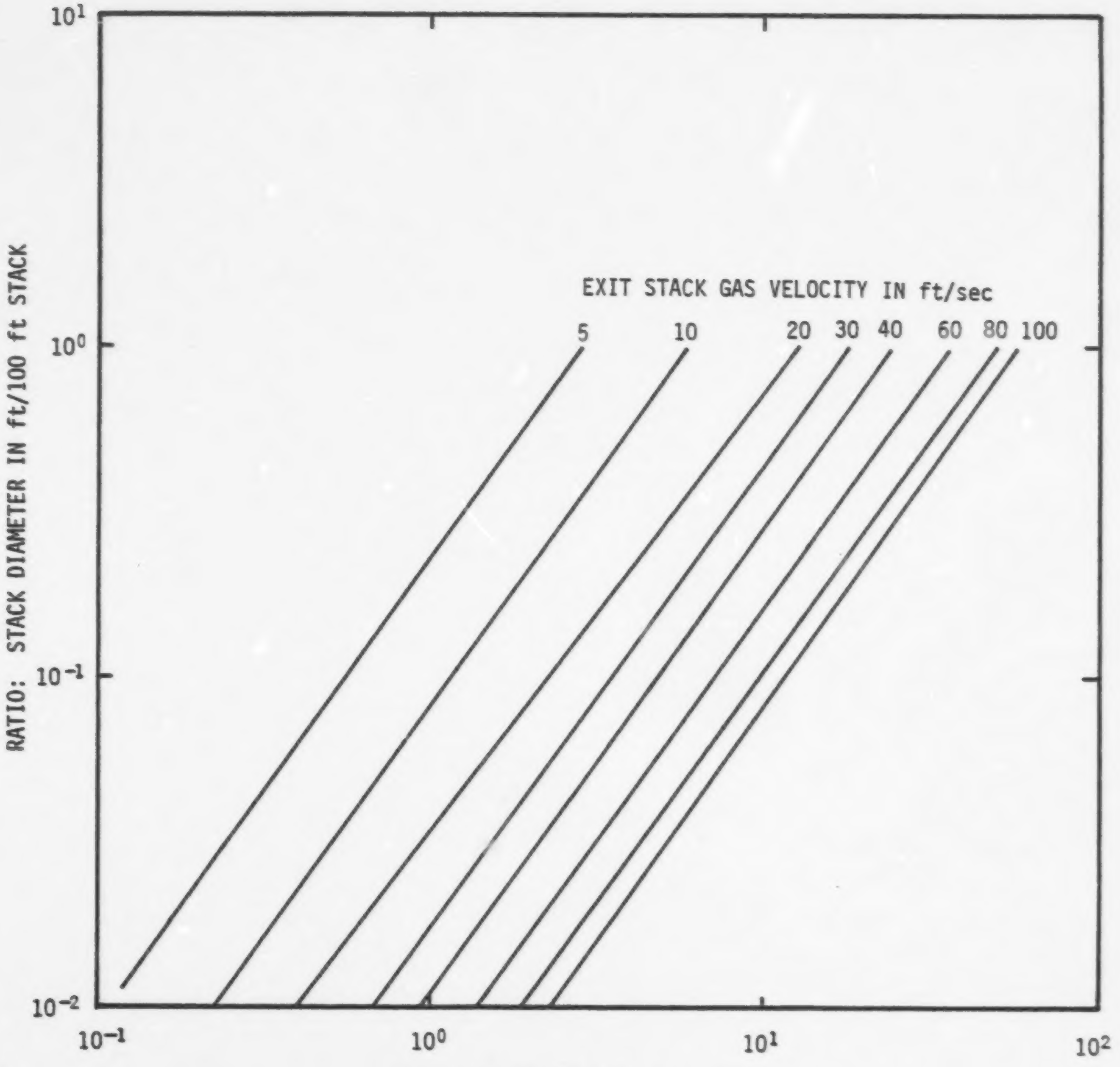
ΔT = temperature difference between stack gas and the outdoor temperatures of 90°F. (550°R) is assumed in preparing dispersion graphs.

T_s = stack exit temperature in °Rankine.

(See Graph 2.)

Figure 7-11. Texas Fluoride Standards.
(Key Excerpts from Regulation III).

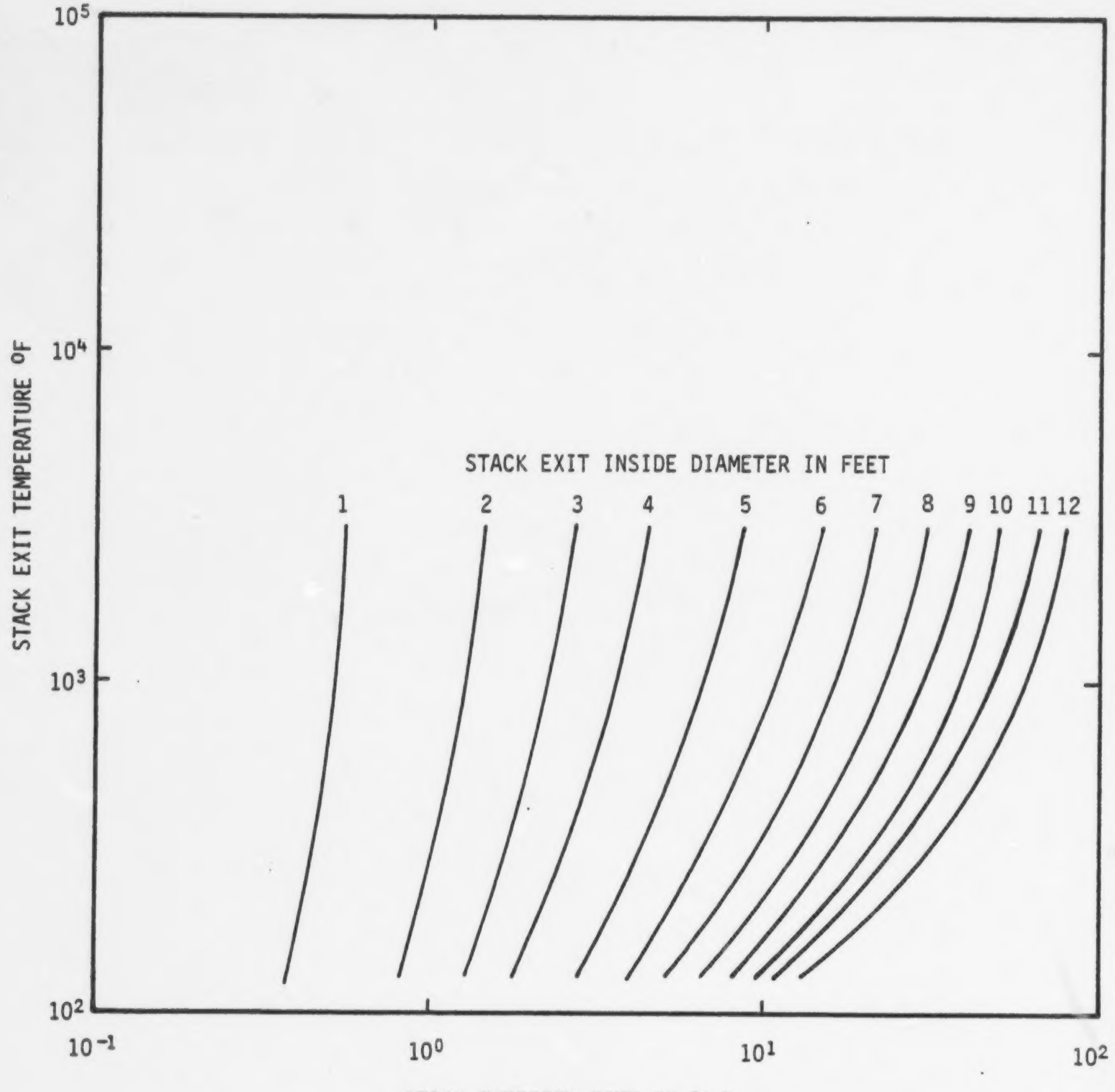
Figure 7-11 (con't)
(Graph 1)



STACK EMISSION RATE IN lb/hr
HYDROGEN FLUORIDE
FOR USE WHEN THE EXIT TEMPERATURE IS LESS THAN 125°F

TO PLOT GRAPH 1, ASSUME A BASIC STACK HEIGHT OF 100 FEET AND PLOTS $\frac{d_s}{100}$ 1.29 FOR VARIOUS STACK DIAMETERS VERSUS STACK VELOCITY.

Figure 7- 11 (con't)
(Graph 2)



STACK EMISSION RATE IN lb/hr
HYDROGEN FLUORIDE
FOR USE WHEN THE EXIT TEMPERATURE IS GREATER THAN 125°F

TO PLOT GRAPH 2, ASSUME A BASIC STACK HEIGHT OF 100 FEET AND AN EXIT VELOCITY OF 20 ft/sec. LET STACK GAS TEMPERATURE VARY WITH STACK DIAMETER.

8. SECONDARY ALUMINUM MANUFACTURING EMISSION ESTIMATES

8.1 INTRODUCTION

Estimates of the atmospheric emissions from the secondary aluminum industry both with current control regulations and with new or revised standards of performance can be made using the data presented in this report and the methodology of Model IV.

Model IV is a methodology developed by EPA's Emissions Standards and Engineering Division which quantitatively estimates the anticipated impact of new or revised standards of performance in reducing atmospheric emissions. Model IV mathematically relates emission producing activities such as industrial growth, and offsetting emission control activities such as existing regulations, New Source Performance Standards (NSPS), and the Clean Air Act. The resulting net emissions are projected for target years.

Using Model IV, the differential in atmospheric emissions that could be expected with and without NSPS can be expressed and the potential for additional controls evaluated. For example, a maximum emission differential or NSPS impact would be observed for an industry for which a stringent standard of performance was technically feasible, but for which there were no existing state emission limitations. On the other hand, a minimum or zero emission differential or impact would be observed for an industry if a standard of performance representing best control technology was generally equal to existing state regulations. NSPS would have little beneficial effects in the latter case in reducing emissions.

TRC, in a 1976 EPA report[1], developed Model IV data and results for approximately 190 industrial categories, including secondary aluminum. Using the data developed in this study, the Model IV input variables can be updated in order to calculate the estimated impact of instituting NSPS based on best available control technology.

8.2 BACKGROUND - MODEL IV PARAMETERS

The impact of new or revised standards of performance is expressed in Model IV as:

$$(T_S - T_N)$$

where: T_S = emissions under baseline year control regulations

T_N = emissions under new or revised standards of performance.

Factors such as increased production capacity, construction to replace obsolete capacity, control technology, and present allowable emissions are used to develop the above relationship. Table 8-1 defines these parameters used in the Model IV equations. From the input variables, T_S and T_N, the total emissions in the i^{th} year under baseline year regulations and revised standards of performance, respectively, are calculated:

$$T_S = E_S K\ (A - B) + E_S K\ (B + C) \quad (8\text{-}1)$$

$$T_N = E_N K\ (A - B) + E_N K\ (B + C) \quad (8\text{-}2)$$

$$T_S - T_N = K\ (B + C)(E_S - E_N) \quad (8\text{-}3)$$

Table 8-1. MODEL IV INPUT VARIABLES

T_S = total emission in i^{th} year under baseline year regulations kg/yr (tons/yr).

T_N = total emissions in i^{th} year under new or revised NSPS which have been promulgated in the j^{th} year kg/yr (tons/yr).

T_U = total emissions in i^{th} year assuming no control kg/yr (tons/yr).

T_A = total emissions in baseline year under baseline year regulations kg/yr (tons/yr).

K = normal fractional utilization rate of existing capacity, assumed constant during time interval.

A = baseline year production capacity (production units/yr).

B = production capacity from construction and modification to replace obsolete facilities (production units/yr).

C = production capacity from construction and modification to increase output above baseline year capacity (production units/yr).

P_B = construction and modification rate to replace obsolete capacity (decimal fraction of baseline capacity/yr).

P_C = construction and modification rate to increase industry capacity (decimal fraction of baseline capacity/yr).

E_S = allowable emissions under existing regulations (mass/unit capacity).

E_N = allowable emissions under standards of performance (mass/unit capacity).

E_U = emissions with no control (mass/unit capacity).

Other related equations are:

1) assumption of compound growth $B = A[(1+P_B)^i-1]$ (8-4)

$C = A[(1+P_C)^i-1]$ (8-5)

2) assumption of simple growth $B = AiP_B$ (8-6)

$C = AiP_C$ (8-7)

where i = elapsed time in years.

3) baseline year emissions $T_A = E_S KA$ (8-8)

4) uncontrolled emissions $T_U = E_U K(A-B) + E_U K(B+C)$ (8-9)

5) for pollutants regulated under Sec. 111(d) of the Clean Air Act.

$$T_{NP} = E_{iii(d)}K(A-B) + E_N K(B+C) \quad (8\text{-}10)$$

where $E_{iii(d)}$ = allowable emissions as required by Section 111(d).

T_{ND} = total emissions in i^{th} year under Section 111(d).

For these calculations the baseline or j^{th} year is defined as 1977 and the i^{th} year, 1987. Simple growth has been assumed.

8.3 EMISSION VARIABLES FOR MODEL IV

Based on the emission factors and control efficiencies presented in Sections 6.4, the emission variables required for input to Model IV can be determined. The pollutants considered were particulates and carbonaceous emissions for sweat furnaces and dryers and chlorine gas, gaseous fluorides, particulates and carbonaceous emissions for reverberatory furnaces. The values of these emission variables and the assumptions used in their determination are presented in the following subsections.

8.3.1 Sweat Furnaces

Particulate has been previously estimated to be emitted from an uncontrolled sweat furnace at a rate of 16.5 kg particulate/1000 kg aluminum produced (33 lb/ton). Then, for uncontrolled emissions:

$$E_{U_P} = 16.5 \text{ kg/1000 kg Al (33 lb/ton Al)}$$

The best available control technology for a sweat furnace is an afterburner followed by a baghouse with a total particulate removal efficiency estimated previously at 94 percent. Therefore, E_{N_P}, the allowable emissions under projected standards of performance, is 6 percent of the uncontrolled emissions or:

$$E_{N_P} = 0.99 \text{ kg/1000 kg Al (1.98 lb/ton Al)}$$

If the average capacity of a sweat furnace is assumed to be 126 kg/ sec (1000 lb/hr) and the product is 60 percent of the feed material[2], the typical process weight rate is 210 kg/sec (1670 lb.hr). The maximum allowable emissions vary by state for the process weight rate of 210 kg/sec. Values for several states with secondary aluminum plants include:

California (South Coast District)	0.42 kg/sec (3.3 lb/hr)
Indiana	0.45 kg/sec (3.6 lb/hr)
Illinois	0.48 kg/sec (3.8 lb/hr)
Ohio	0.45 kg/sec (3.6 lb/hr)

While there is not a specific geographical distribution for all of the 84 smelters in the U. S., a generalized process weight rate curve can be utilized.[1] This curve is based on the average state regulations for particulates and is presented in Figure 8-1. Based on this curve, an allowable rate of 0.47 g/sec (3.7 lb/hr) was chosen as being representative. Therefore, for the 126 g/sec of aluminum produced, the allowable emissions under existing regulations are:

$$E_{S_P} = 3.7 \text{ kg/1000 kg Al (7.4 lb/ton Al)}$$

Uncontrolled emission factors for the carbonaceous emissions (hydrocarbons and carbon monoxide) generated by sweat furnaces were not obtainable through literature or test data. However, these factors can be approximated via the following analysis. Industry contacts indicate that oils are typically four percent of borings weight and coatings are five to eight percent of the weight of architectural sidings and beverage cans. Since scrap with most organic contamination is dryer treated, while scrap with less contamination goes to sweat and reverberatory furnaces, assume that the average content of organic compounds in scrap to dryers and furnaces is four percent and one percent, respectively. Since oxygen to dryers and furnaces is limited to minimize aluminum loss, assume that only half of the organics are oxidized completely to CO_2 to H_2O and that the remainder is converted by pyrolysis and partial oxidation to equal quarter fractions of particulate carbon, condensible hydrocarbons (HC), gaseous HC, and CO.

The uncontrolled emission factors for HC and CO for sweat furnaces would thus be:

1.25 kg condensible HC/1000 kg Al (2.5 lb/ton Al)
1.25 kg gaseous HC/1000 kg Al (2.5 lb/ton Al)
1.25 kg CO/1000 kg Al (2.5 lb/ton Al)

Combining these yields the uncontrolled emission factor for carbonaceous emissions from sweat furnaces:

$$E_{U_c} = 3.8 \text{ kg/1000 kg Al (7.5 lb/ton Al)}$$

It is assumed that there are no state regulations for HC and CO from secondary aluminum plants[1] and so:

$$E_{S_c} = E_{U_c}$$

The best available control technology for carbonaceous emissions has been shown to be an afterburner with an efficiency of 99 percent (See Table 6-8). Therefore:

$$E_{N_c} = 0.04 \text{ kg/1000 kg Al (0.08 lb/ton Al)}$$

8.3.2 Chip Dryers

Particulate has been previously estimated to be emitted from an uncontrolled chip dryer at an average rate of approximately 10.5 kg/ 1000 kg Al (21 lb/ton Al). Therefore:

$$E_{U_P} = 10.5 \text{ kg/1000 kg Al (21 lb/ton Al)}$$

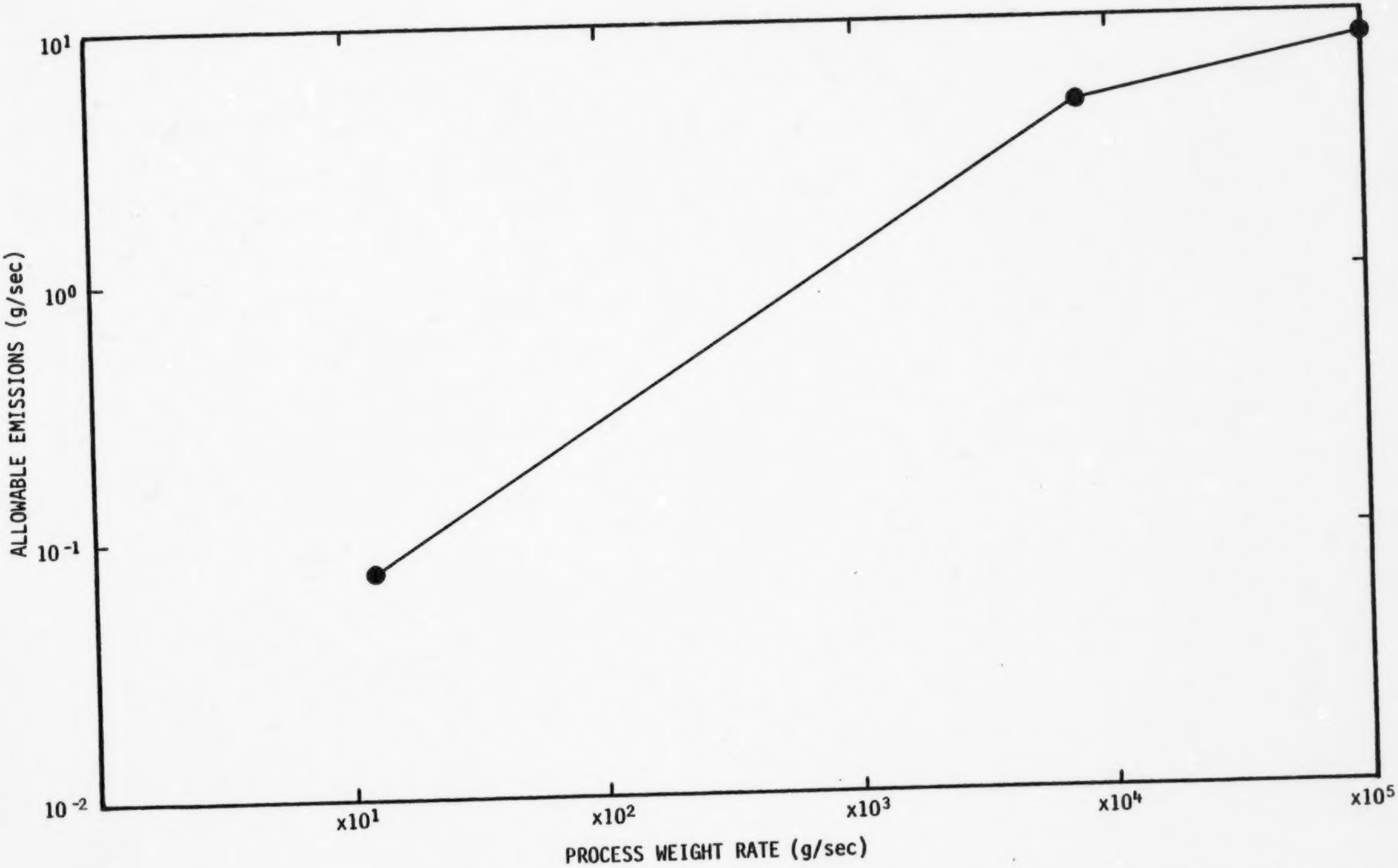


Figure 8-1. Average of state regulations applicable to general process sources-particulates

Like sweat furnaces, the best available control technology for a chip dryer is an afterburner followed by a baghouse with an efficiency of 94 percent. Therefore:

$$E_{N_P} = 0.63 \text{ kg/1000 kg Al (1.26 lb/ton Al)}$$

Utilizing the generalized process weight rate curve for a typical chip dryer process weight rate of 277 g/sec (220 lb/hr) yields 0.57 g/sec (4.5 lb/hr) allowable emissions. Assuming 271 g/sec (2150 lb/hr) of aluminum are produced from the 277 g/sec fed to the dryer, the allowable emissions under the existing regulations are:

$$E_{S_P} = 2.1 \text{ kg/1000 kg Al (4.2 lb/ton Al)}$$

The above process weight rate and production ratio were obtained through a variety of industrial contacts.

Based on the analysis of carbonaceous emissions presented in the previous section, the uncontrolled emission factors for chip dryers are:

5 kg condensible HC/1000 kg Al (10 lb/ton Al)
5 kg gaseous/1000 kg Al (10 lb/ton Al)
5 kg CO/1000 kg Al (10 lb/ton Al)

Combining these yields the emission factor for carbonaceous emissions from chip dryers:

$$E_{U_c} = 15 \text{ kg/1000 kg Al (30 lb/ton Al)}$$

As with sweat furnaces, there are no state regulations for HC and CO and an afterburner with 99 percent efficiency is the BACT. Thus:

$$E_{U_c} = E_{S_c}$$

$$E_{N_c} = 0.15 \text{ kg/1000 kg Al } (0.30 \text{ lb/ton Al})$$

8.3.3 Reverberatory Furnaces

The following uncontrolled emission factors for particulate have been previously estimated for reverberatory furnaces (See Table 6-7):

Charging: 2.2 kg/1000 kg Al (4.3 lb/ton Al)

Demagging: 500 kg/1000 kg Cl_2 (1000 lb/ton Cl_2)

12 kg/1000 kg F_2 (24 lb/ton AlF_3)

Actual reverberatory furnace capacities vary. A range of 22,680-38,560 kg (50,000-80,000 lbs) capacity was found via the plant correspondence. A capacity of 34,020 kg (75,000 lbs) was selected as average with a 24 hour batch cycle. This converts to 0.39 kg Al/sec (1.56 ton Al/hr). A typical chlorine addition for a 34,020 kg capacity furnace is 76 g/sec (600 lb/hr).[1] For this amount of chlorine, 38 g/sec (300 lb/hr) of particulate will be emitted based on the emission factor. This same amount (76 g/sec) is also a typical aluminum fluoride addition according to industrial contacts. For this amount of aluminum fluoride, 0.91 g/sec (7.2 lb/ hr) of particulate will be emitted. It is estimated that the number of plants using chlorine for demagging is roughly twice the number that use fluoride.[3] Therefore, the uncontrolled emission variable for an average plant is:

$$E_{U_P} = \left[2.2 + \left(\frac{2}{3}\right)\left(\frac{38}{0.39}\right) + \left(\frac{1}{3}\right)\left(\frac{0.91}{0.39}\right)\right] \text{ kg/1000 kg Al}$$
$$= 67.9 \text{ kg/1000 kg Al } (136 \text{ lbs/ton Al})$$

The best available control devices for reverberatory furnaces have been shown to be the coated baghouse and the wet scrubber "bell" system. Both systems are roughly 98 percent efficient for particulate removal, as noted previously. Therefore:

$$E_{N_P} = 1.36 \text{ kg/1000 kg Al (2.7 lbs/ton Al)}$$

The allowable emissions of particulates depend upon the quantity of flux and scrap aluminum fed into the reverberatory furnace and the feed to product ratio. The amount of flux varies with the material charged, with amounts of less than 10 percent to 33 percent of the weight of the charged material.[1] For the maximum allowable emissions, flux equal to 33 percent will be utilized in the calculations. A typical product to feed ratio is 0.9 kg Al/kg scrap.[1] The process weight rate is thus:

$$\frac{(34020)(1.333)(1000)}{(0.9)(24)(3600)} = 583 \text{ g/sec (4630 lb/hr)}$$

For a process weight of 583 g/sec, 0.95 g/sec (7.5 lb/hr) of particulate can be emitted utilizing Figure 8-1. The allowable emission variable is thus:

$$E_{S_P} = 2.4 \text{ kg/1000 kg Al (4.8 lbs/ton Al)}$$

Uncontrolled gaseous emissions from demagging have been previously estimated to be 29 kg/1000 kg AlF_3 (58 lb/ton AlF_3) and about 200 kg/1000 kg Cl_2 (400 lb/ton Cl_2) (See Table 6-7). The emission variables are therefore:

$$E_{U_{\text{gaseous fluorides}}} = \frac{\left(\frac{\text{29 kg gaseous fluorides}}{\text{1000 kg AlF}_3\text{ Feed}}\right)\left(\frac{\text{0.76 kg AlF}_3\text{ Feed}}{\text{Sec}}\right)(1000)}{\left(0.39\ \frac{\text{kg Al}}{\text{sec}}\right)}$$

$$= 5.7 \text{ kg/1000 kg Al (11.3 lb/ton Al)}$$

$$E_{U_{Cl_2}} = \frac{\left(\frac{\text{200 kg Cl}_2}{\text{1000 kg Cl}_2\text{ Feed}}\right)\left(\frac{\text{0.76 kg Cl}_2\text{ Feed}}{\text{Sec}}\right)(1000)}{\left(0.39\ \frac{\text{kg Al}}{\text{sec}}\right)}$$

$$= 39.0 \text{ kg/1000 kg Al (78.0 lb/ton Al)}$$

As shown previously, these emissions can be reduced 99.8 percent using either the scrubber or coated baghouse. Therefore,

$$E_{N_{\text{gaseous fluorides}}} = 0.01 \text{ kg/1000 kg Al } (0.02 \text{ lb/ton Al})$$

$$E_{N_{Cl_2}} = 0.08 \text{ kg/1000 kg Al } (0.16 \text{ lb/ton Al})$$

Since no state containing a secondary aluminum plant has a regulation for chlorine emissions, assume:

$$E_{S_{Cl_2}} = E_{U_{Cl_2}} = 39 \text{ kg/1000 kg Al } (78 \text{ lb/ton Al})$$

Since the majority of the states do not have regulations for gaseous fluoride emissions, assume:

$$E_{S_{\text{gaseous fluorides}}} = E_{U_{\text{gaseous fluorides}}} = 5.7 \text{ kg/1000 kg Al } (11.3 \text{ lb/ton Al})$$

The uncontrolled emission factors for carbonaceous emissions for reverberatory furnaces are identical to those for sweat furnaces, as discussed in Section 8.3.1. Likewise, there are no state regulations and an afterburner is the BACT. Therefore:

$$E_{U_c} = E_{S_c} = 3.8 \text{ kg/1000 kg Al } (7.5 \text{ lb/ton Al})$$

$$E_{N_c} = 0.04 \text{ kg/1000 kg Al } (0.08 \text{ lb/ton Al})$$

8.4 INDUSTRIAL FACTORS FOR MODEL IV

Based on the information presented in Section 4.0, the industrial factors required for input to Model IV can be determined. These factors are discussed in the following subsections.

8.4.1 K Factor

The factor K is the normal fractional utilization rate of existing capacity. A factor for the sweat furnace (K_{sweat}) was chosen as 0.67, based on industrial contact and literature values for secondary lead sweat furnaces which are essentially interchangeable with those used in the aluminum industry.

No information was specifically available concerning K for reverberatory furnaces. However, using the capacity utilization factor for advanced process non-ferous metals, $K_{reverb.}$ was set at 0.82.[1] This correlates well with data from one plant visited where 5 of 6 furnaces were in continual operation.

Plant data demonstrated that, in many cases, chip dryers were operating three shifts per day or near maximum capacity. Therefore, K_{dryers} was set at 0.9.

8.4.2 P_C Factor

P_C, the construction rate to increase industry capacity, has historically increased 20 percent every three years since World War II. However, due to economic conditions, the Aluminum Recycling Association predicts a slower rate of growth in the next ten years. The industrial growth factor has thus been estimated at 2 percent per year and P_C = 0.02.

8.4.3 P_B Factor

The P_B factor is defined as the construction and modification rate to replace obsolete capacity. In this case, P_B was assumed to be twice the IRS depreciation allowance for the manufacturing of nonferrous metals.[1] P_B was then set equal to 0.036.

8.4.4 A Factor

The A factor is the baseline production capacity and varies between sweating, reverberatory, and drying operations. According to industrial contacts and the Bureau of Mines, the 1977 production of secondary aluminum was on the order of 454 x 10^6 kg (0.5 x 10^6 tons). It is assumed that 20 percent of the scrap goes to the chip dryer, 20 percent to the sweat furnaces and 100 percent to the reverberatory furnaces.[4]

The 1977 baseline production capacity, A, is the ratio of production to utilization factor. Therefore:

$$A_{sweat} = \frac{(453 \times 10^6 \text{ kg})(0.2)}{0.67} = 135 \times 10^6 \text{ kg Al } (0.15 \times 10^6 \text{ tons Al})$$

$$A_{dryer} = \frac{(453 \times 10^6 \text{ kg})(0.2)}{0.9} = 101 \times 10^6 \text{ kg Al } (0.11 \times 10^6 \text{ tons Al})$$

$$A_{reverb} = \frac{(453 \times 10^6 \text{ kg})}{0.82} = 552 \times 10^6 \text{ kg Al } (0.61 \times 10^6 \text{ tons Al})$$

8.5 SUMMARY OF MODEL IV INPUT PARAMETERS

Table 8-2 summarizes the Model IV industrial and emission factors for the secondary aluminum industry. Capacity factors B and C, defined in Table 8-1, were calculated using equations 8-6 and 8-7.

8.6 MODEL IV RESULTS

Utilizing the input parameters outlined in Table 8-2 and equations 8-1, 8-2, 8-3, and 8-9, estimates can be made of both uncontrolled emissions and the 1987 impact of the performance standards. Table 8-3 presents the results of the calculations.

As shown in the table, NSPS would have the maximum impact on HC and CO, chlorine and gaseous fluoride control. This is due to the lack of current state regulations regarding these pollutants.

The emission reduction for particulates is smaller than for other secondary metal industries such as copper, cast iron and steel foundries, but greater than brass, bronze, lead and zinc smelting.[1] Apparently, the existing state regulations are fairly adequate as regards particulate matter.

Table 8-2. MODEL IV INDUSTRIAL AND EMISSION FACTORS

Process/Pollutant	Emission Factors			K	Growth Rates		Industry Capacity		
	E_U	E_S	E_N		P_B	P_C	A	B	C
	kg/1000 kg Al (lb/ton Al)				Per Yr.		kg/yr (tons/yr) aluminum		
Sweat Furnaces/				0.67	0.036	0.02	135×10^6 (0.15×10^6)	49×10^6 (0.05×10^6)	27×10^6 (0.03×10^6)
Particulates	16.5 (33.0)	3.7 (7.4)	0.99 (1.98)						
HC and CO	3.8 (7.5)	3.8 (7.5)	0.04 (0.08)						
Chip dryers/				0.90	0.036	0.02	101×10^6 (0.11×10^6)	36×10^6 (0.04×10^6)	20×10^6 (0.02×10^6)
Particulates	10.5 (21.0)	2.1 (4.2)	0.63 1.26						
HC and CO	15.0 (30.0)	15.0 (30.0)	0.15 (0.30)						
Reverberatory Furnaces/				0.82	0.036	0.02	522×10^6 (0.61×10^6)	199×10^6 (0.22×10^6)	110×10^6 (0.12×10^6)
Particulates	67.9 (13.6)	2.4 (4.8)	1.36 (2.7)						
HC and CO	3.8 (7.5)	3.8 (7.5)	0.04 (0.08)						
Chlorine	39.0 (78.0)	39.0 (78.0)	0.08 (0.16)						
Gaseous Fluorides	5.7 (11.3)	5.7 (11.3)	0.01 (0.02)						

Table 8-3. MODEL IV RESULTS

Process/Pollutant	Total Emissions in 1987 T_U	 T_S	 T_N	Impact of Standards $T_S - T_N$ kg/yr (tons/yr)
	kg/yr (tons/yr)			
Sweat furnaces/ particulates	1,791,000 (1,974)	401,600 (443)	107,450 (118)	294,150 (325)
HC and CO	412,400 (452)	412,400 (452)	4,120 (5)	408,280 (447)
Chip dryers/ particulates	1,143,500 (1,260)	228,700 (252)	68,610 (76)	160,090 (176)
HC and CO	1,633,500 (1,755)	1,633,500 (1,755)	16,340 (18)	1,617,160 (1,737)
Reverberatory furnaces/ particulates	36,859,000 (40,630)	1,302,800 (1,436)	738,260 (814)	564,540 (622)
HC and CO	2,062,800 (2,245)	2,062,800 (2,245)	20,630 (22)	2,042,170 (2,223)
Chlorine	21,171,000	21,171,000	43,340	21,128,660
Gaseous Fluorides	3,094,200 (3,382)	3,094,200 (3,382)	5,970 (7)	3,008,230 (3,375)

REFERENCES FOR SECTION 8

1. Hopper, Thomas G. and William A. Marrone. Impact of New Source Performance Standards on 1985 National Emissions from Stationary Sources. (Vol. I). The Research Corporation of New England. TRC Project No. 32391. Wethersfield, Connecticut. October 1975.

2. Hardison, L. C. and H. R. Herington. Study of Technical and Cost Information for Gas Cleaning Equipment in the Lime and Secondary Non-Ferrous Metallurgical Industries. Industrial Gas Cleaning Institute, Inc., Rye, NY. Report Number PB-198-137. December 1970. 293 p.

3. Train, Russell E., Roger Strelow, Allen Cywin, and George S. Thompson, Jr. Development Document for Effluent Limitations Guidelines and New Source Performance Standards for the Second Aluminum Smelting Subcategory of the Non-Ferrous Metals Manufacturing Point Source Category. U. S. EPA, Washington, DC. Report Number PB-238-464. March 1974. 131 p.

4. Ginsbery, T. H. Scrap Utilization by Secondary Aluminum Smelters. In: Proceedings of the Third Mineral Waste Utilization Symposium. Chicago, IL, March 14-16, 1972. 269-273 p.

9. SAMPLING AND ANALYSIS METHODS FOR EMISSIONS FROM SECONDARY ALUMINUM MANUFACTURING

Table 9-1 presents a list of the substances identified previously as being potentially emitted from the secondary aluminum manufacturing process and the sampling and analysis methodology to be used for each one of them. EPA Reference Methods can be used to measure the particulate, carbon monoxide and fluoride emissions. There are no Reference Methods for the metals listed, but the Reference Method for Beryllium can be adapted to them by analyzing the collected sample using atomic absorption spectrophotometry at the optimum analytical wavelength for each specific metal. Total hydrocarbons can be measured by modifying the Intersociety Committee Method 108. This modification consists of maintaining the temperature of a sample stream at a level at which condensation does not occur and then using an analyzer which has heat traced lines that maintain the temperature of the gas stream to the detector. The sampling and analysis for HCl is based on sampling by EPA Method 6 and analysis by the Argentometric Method.

Determination of the emission rates is basically the same for all of the potentially emitted substances. It is necessary to measure the concentration of the substance by analyzing a sample which is representative of that in the duct or stack and which is characteristic of normal process operating conditions. It is also necessary to measure the volumetric flow rate of the gases in the duct or stack at the time of sampling. The substance mass emission rate is then calculated from the measured concentration and volumetric flow rate.

The following sections contain concise descriptions of the recommended sampling and analysis methods for the emissions from the secondary aluminum manufacturing process. Not all methods have documented precision and accuracy and this information is provided only as available in the literature.

Table 9-1. SAMPLING AND ANALYSIS TECHNIQUES FOR THE SUBSTANCES POTENTIALLY EMITTED FROM THE SECONDARY ALUMINUM MANUFACTURING PROCESS

Substance	Sampling Technique	Analysis Technique
Particulate	Isokinetic with collection on glass fiber filter	Gravimetric
Carbon monoxide	Integrated bag or continuous	NDIR (Non-dispersive Infrared)
Fluorides (including HF)	Isokinetic with cellulose filter and impingers with distilled water	SPADNS - Zirconium Lake or specific ion electrode
Aluminum as $AlCl_3$ and Al_2O_3	Isokinetic with membrane filter and impingers with distilled water	Atomic absorption at a wavelength of 309.3 nm
Calcium as $CaCl_2$	Isokinetic with membrane filter and impingers with distilled water	Atomic absorption at a wavelength of 422.7 nm
Magnesium as M_gCl_2 and M_gO	Isokinetic with membrane filter and impingers with distilled water	Atomic absorption at a wavelength of 285.2 nm
Sodium as NaCl	Isokinetic with membrane filter and impingers with distilled water	Atomic absorption at a wavelength of 589.6 nm
Zinc as ZnCl and ZnO	Isokinetic with membrane filter and impingers with distilled water	Atomic absorption at a wavelength of 213.9 nm
Total hydcrocarbons	Heated line to analyzer	FID (Flame Ionization Method)
Chlorides (as HCl and Cl_2	Sampled proportional to duct velocity through midget bubbler containing sodium hydroxide for HCl and alkaline arsenite for Cl_2	Argentometric Method

9.1 PARTICULATE

Particulate emission rates can be measured using the sampling and analysis techniques specified by Method 5 - Determination of Particulate Emissions from Stationary Sources[1] or Method 17 - Determination of Particulate Emissions from Stationary Sources (Instack Filtration Method).[2] Sampling and analysis procedures in both methods are essentially the same with the only difference being the location of the filter. Method 5 has a filter located outside the stack and thus the sample stream temperature must be maintained above the condensation point. Diagrams of the sampling trains for Methods 5 and 17 are presented in Figures 9-1 and 9-2, respectively.

In Methods 5 and 17, a representative sample of particulate in the duct or stack is collected by extracting samples from the centroids of several equal areas in the cross section of the duct or stack. The number of equal areas required to be sampled is a function of the distance of the sampling cross section from any upstream and downstream flow disturbances. The sample stream is extracted from the main stream isokinetically, which means that the velocity of the sample stream in the nozzle is equal to that in the duct or stack at the point being sampled. Isokinetic sampling is required to assure that the measured concentration is the same as that in the duct and is not influenced by the particle inertia. The velocity of the gas in the duct is measured by a pitot tube and the sampling rate necessary to have a velocity in the nozzle equal to that in the duct is calculated after measurement by a calibrated orifice. In Method 17, the sample stream passes directly from the nozzle through a preweighed glass fiber filter which removes the particulate. In Method 5, the sample stream passes through a heated probe and through a pre-weighed glass fiber filter, which is located in an oven to prevent any condensation. The sample stream is drawn through a condenser and drying column to an airtight

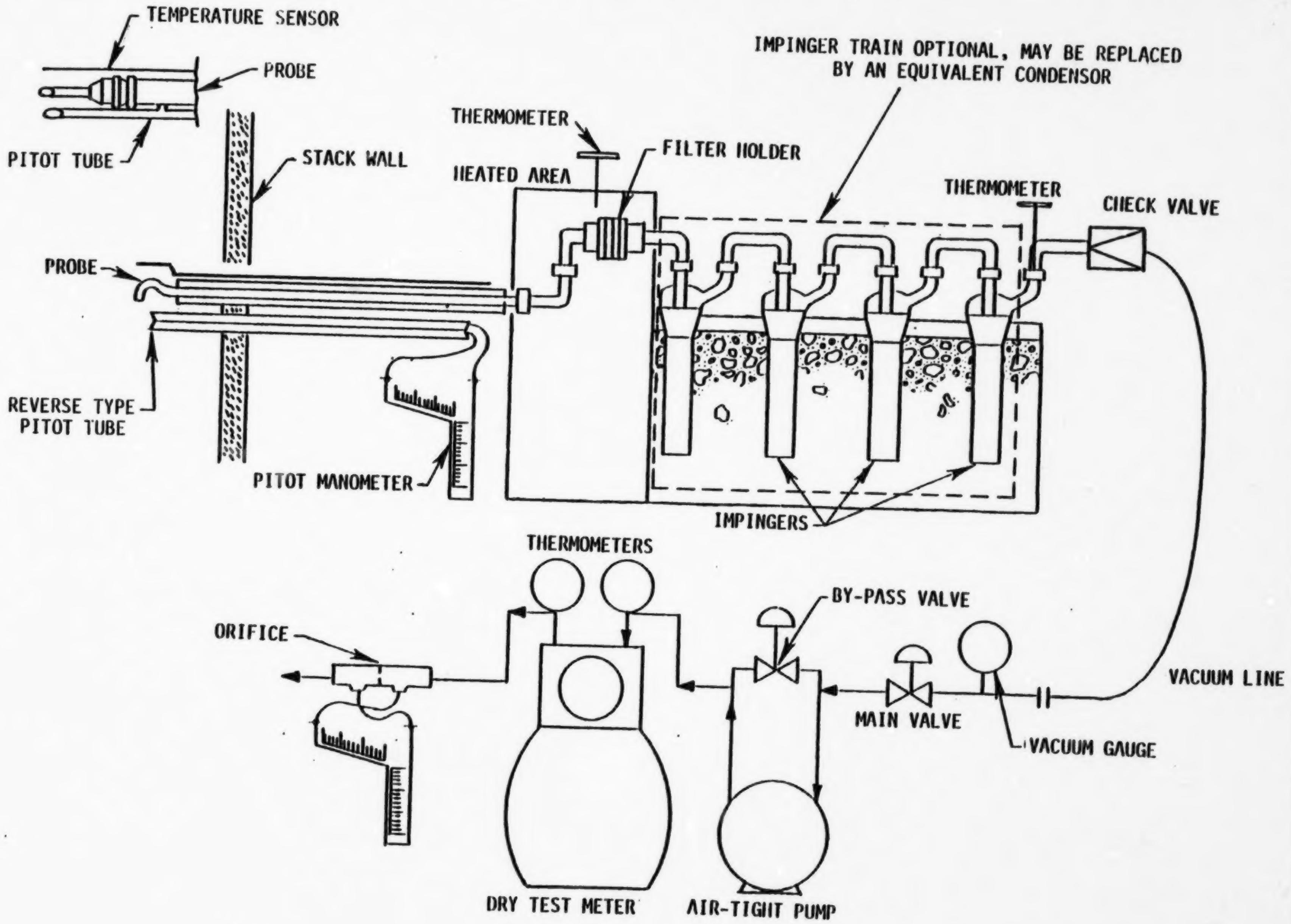

TEMPERATURE SENSOR
PROBE
PITOT TUBE
STACK WALL
PROBE
REVERSE TYPE PITOT TUBE
PITOT MANOMETER
THERMOMETER
HEATED AREA
FILTER HOLDER
IMPINGER TRAIN OPTIONAL, MAY BE REPLACED BY AN EQUIVALENT CONDENSOR
THERMOMETER
CHECK VALVE
IMPINGERS
THERMOMETERS
BY-PASS VALVE
ORIFICE
VACUUM LINE
MAIN VALVE
VACUUM GAUGE
DRY TEST METER
AIR-TIGHT PUMP

Figure 9-1. Method 5 particulate-sampling train

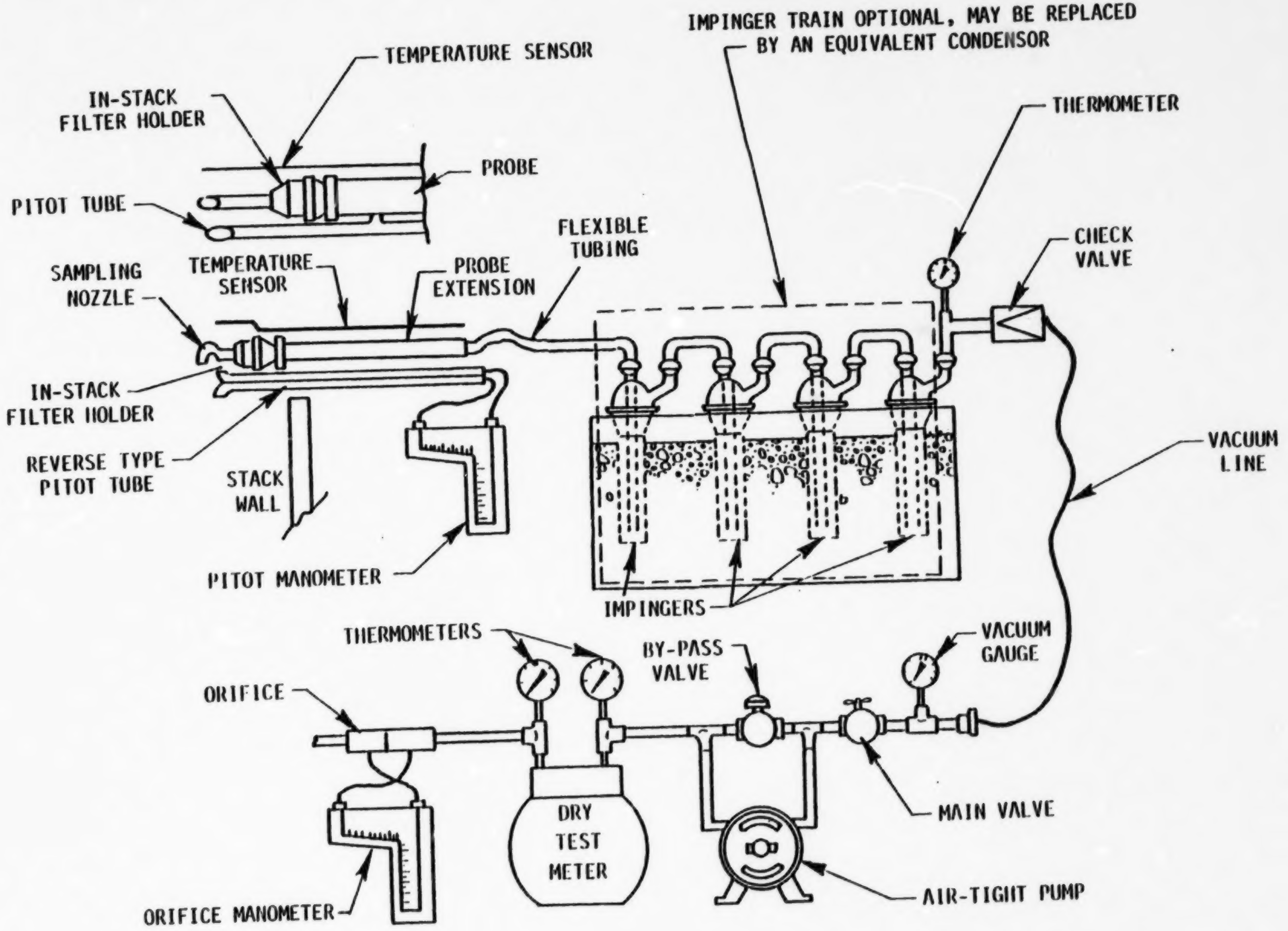

IMPINGER TRAIN OPTIONAL, MAY BE REPLACED BY AN EQUIVALENT CONDENSOR
TEMPERATURE SENSOR
IN-STACK FILTER HOLDER
PROBE
PITOT TUBE
THERMOMETER
FLEXIBLE TUBING
CHECK VALVE
SAMPLING NOZZLE
TEMPERATURE SENSOR
PROBE EXTENSION
IN-STACK FILTER HOLDER
REVERSE TYPE PITOT TUBE
STACK WALL
VACUUM LINE
PITOT MANOMETER
IMPINGERS
THERMOMETERS
BY-PASS VALVE
VACUUM GAUGE
ORIFICE
DRY TEST METER
MAIN VALVE
ORIFICE MANOMETER
AIR-TIGHT PUMP

Figure 9-2. Method 17 particulate-sampling trian, equipped with in-stack filter

pump. The pump discharges through a calibrated dry gas meter which measures the volume sampled and then exhausts through a calibrated orifice which measures the sampling rate. Upon completion of sampling, the filter is carefully removed from the holder and any particulate in the nozzle and probe is washed into a sample container. The filter and wash are dried and dessicated and weighed. The total weight of particulate collected on the filter and in the nozzle and probe is divided by the sample volume measured by the dry gas meter and corrected to standard conditions. This is then multiplied by the volumetric flow rate measured by the pitot tube and corrected to standard conditions.

9.2 CARBON MONOXIDE

Carbon monoxide emission rates can be measured using the sampling and analysis techniques specified in Method 10 - Determination of Carbon Monoxide Emissions from Stationary Sources.[3] Method 10 specifies that either an integrated or continuous sample stream is to be extracted.

Integrated sampling involves collecting a sample in a bag at a rate proportional to the duct velocity. The sample stream is extracted from the duct through a glass wool filter to remove any particulate. The sample stream then passes through a condenser and flow meter into a bag which is inside an evacuated container. Upon completion of sampling, the bag is connected to an analysis system which consists of a drying tube and a CO_2 removal tube (since moisture and CO_2 interfere with the CO analysis), connections for span and zero gas and a non-dispersive infrared (NDIR) analyzer which measures the CO concentration. The continuous monitoring system consists of the probe and condenser attached directly to the analysis system. The precision and accuracy of most NDIR analyzers are approximately ± 2 per cent and ± 5 percent, respectively.

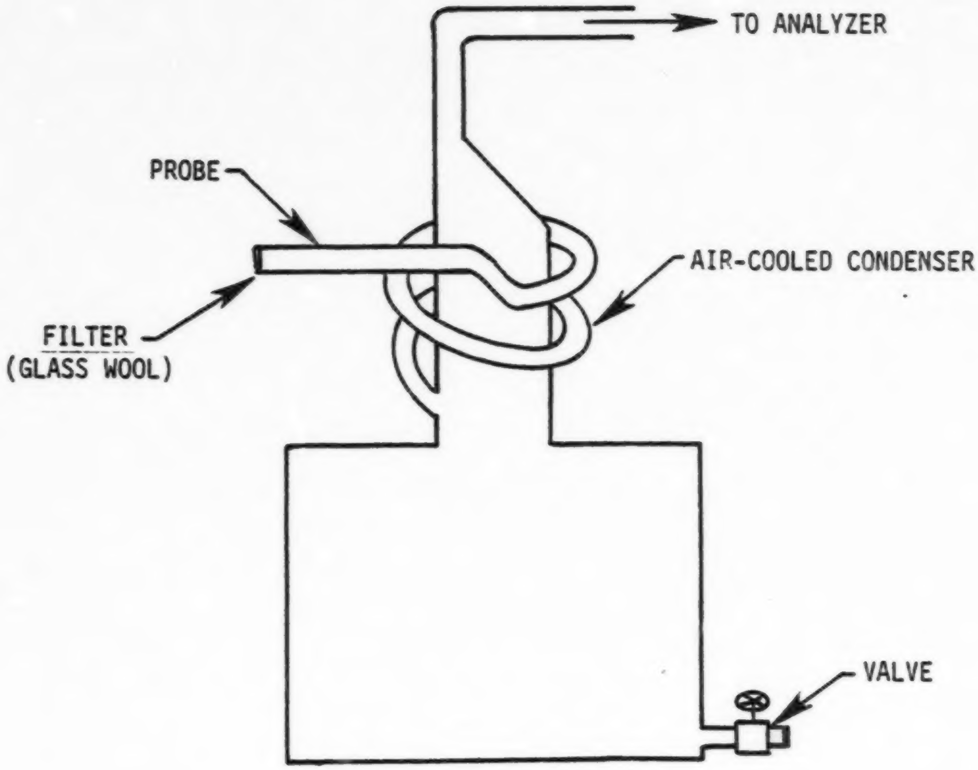

TO ANALYZER
PROBE
AIR-COOLED CONDENSER
FILTER
(GLASS WOOL)
VALVE

Figure 9-3. Method 10 continuous sampling train

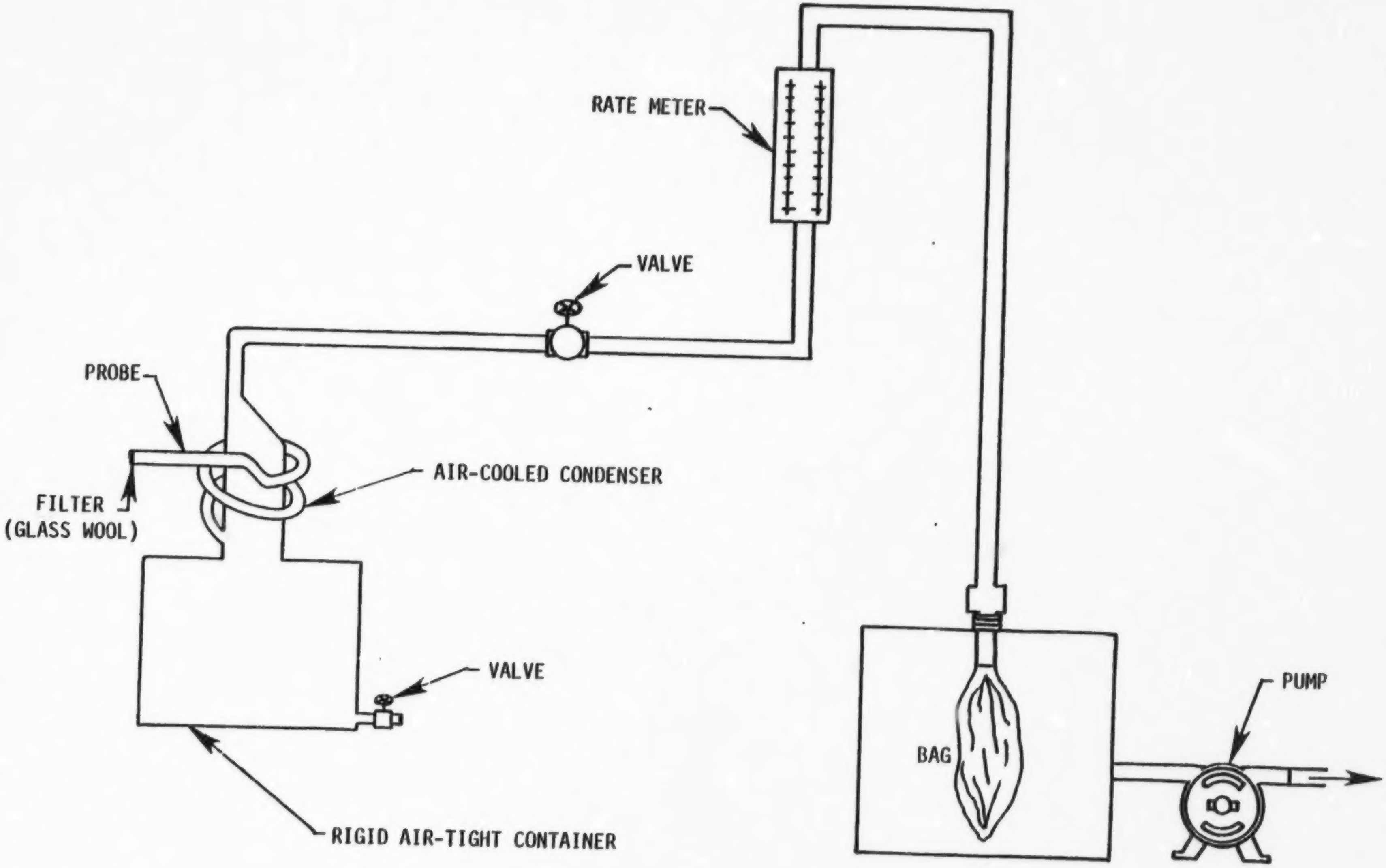

RATE METER
VALVE
PROBE
AIR-COOLED CONDENSER
FILTER
(GLASS WOOL)
VALVE
PUMP
BAG
RIGID AIR-TIGHT CONTAINER

Figure 9-4. Method 10 integrated gas sampling train

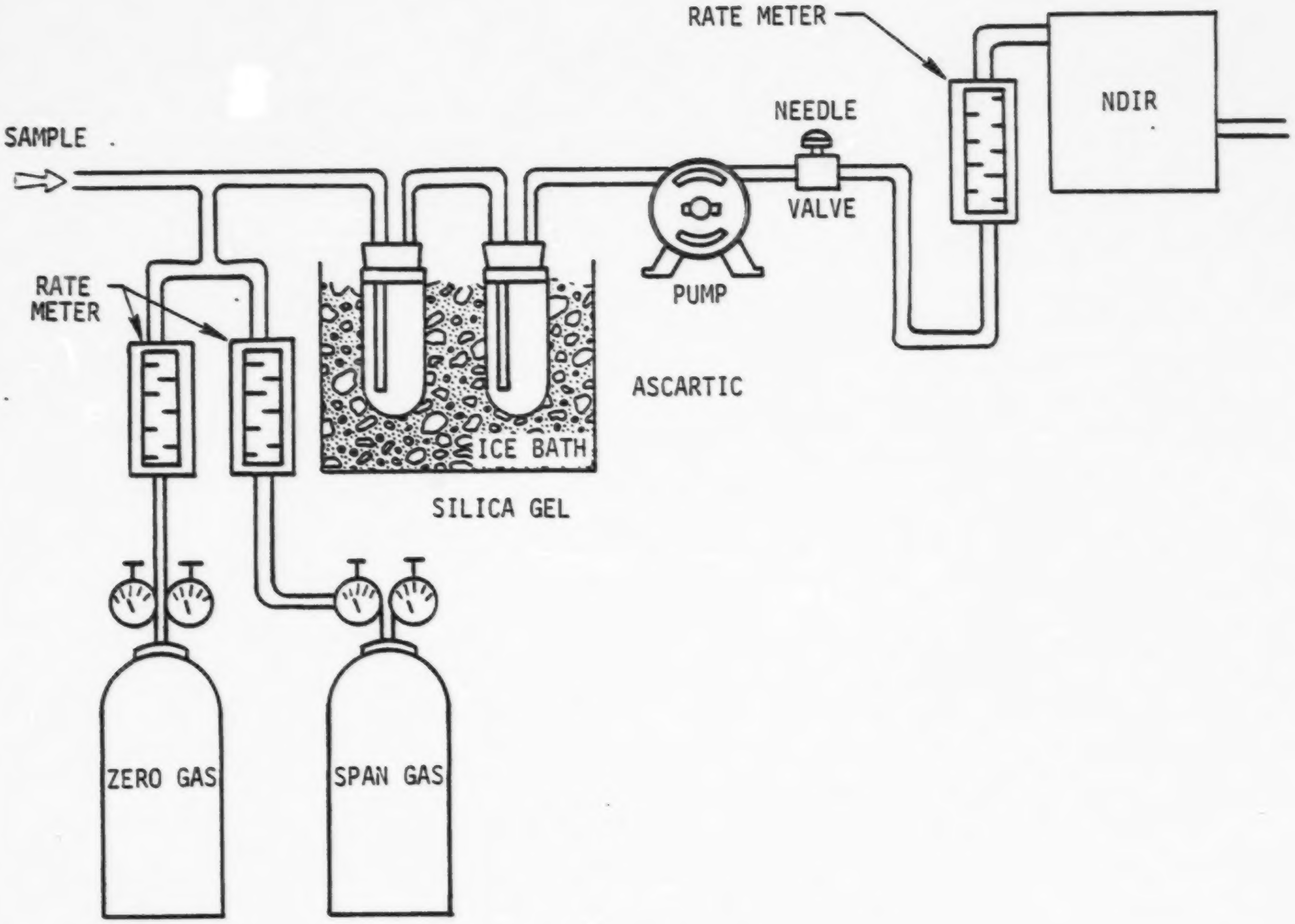

SAMPLE
RATE METER
NEEDLE
VALVE
NDIR
PUMP
RATE METER
ASCARTIC
ICE BATH
SILICA GEL
ZERO GAS
SPAN GAS

Figure 9-5. Method 10 analytical equipment

The Method 10 continuous sampling train, integrated gas sampling train and analytical equipment are shown in Figures 9-3, 9-4 and 9-5, respectively.

9.3 TOTAL FLUORIDES

The emission rates of total fluorides can be measured using the sampling and analysis techniques specified in either Method 13 - Determination of Total Fluoride Emissions from Stationary Sources - SPADNS Zirconium Lake Method[4] or Method 13 B - Determination of Total Fluoride Emissions from Stationary Sources - Specific Ion Electrode Method.[4] The sample collection system and technique are similar to that described in Method 5 for particulate in that a representative sample is collected from the duct gas by isokinetically sampling at the centroids of equal areas of the duct cross section. The sample temperature is maintained to prevent condensation in the probe. The sample is extracted from the duct through the nozzle and probe and through the impingers, the first two of which contain distilled water. Any particulate penetrating the impingers is collected on a cellulose filter located between the third impinger and the drying tube. The sample then flows through a pump, dry gas meter and calibrated orifice (Figure 9-6).

Upon completion of sampling, the filter, impinger catch, probe wash and impinger wash are placed in a sample container. The weight of total fluorides collected is determined either by the SPADNS Zirconium Lake colorimetric method or by a specific ion electrode. To obtain the emission rate, the weight of the total fluorides is divided by the sample volume corrected to standard conditions and multiplied by the volumetric flow rate in the duct corrected to standard conditions.

Analysis by the SPADNS Zirconium Lake colorimetric method of twenty replicate stack emission samples with a concentration range of 39 to 360 mg/l resulted in a relative standard deviation of 3 per cent. A phosphate rock

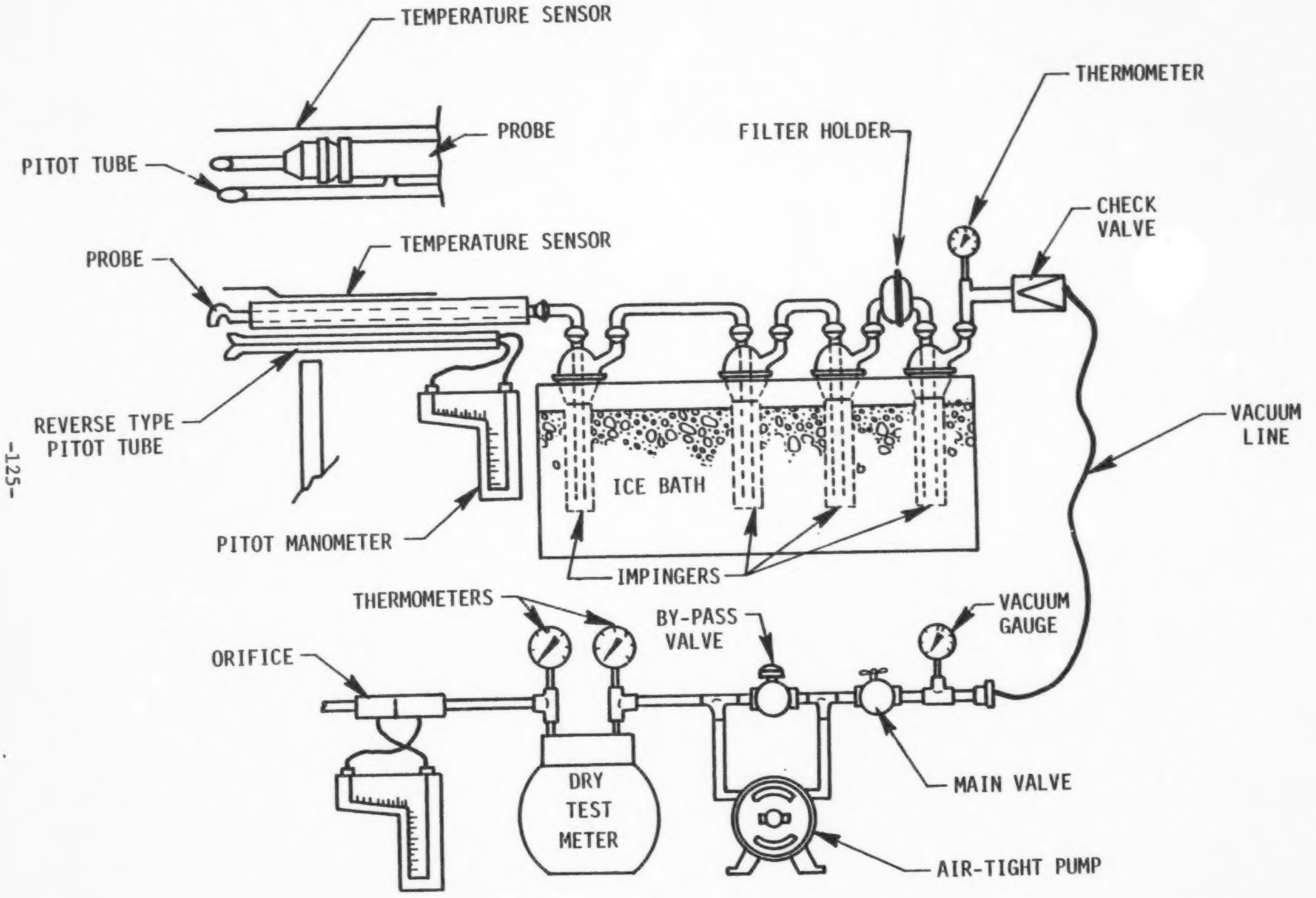

TEMPERATURE SENSOR
PROBE
PITOT TUBE
THERMOMETER
FILTER HOLDER
CHECK VALVE
PROBE
TEMPERATURE SENSOR
REVERSE TYPE PITOT TUBE
VACUUM LINE
ICE BATH
PITOT MANOMETER
IMPINGERS
THERMOMETERS
BY-PASS VALVE
VACUUM GAUGE
ORIFICE
DRY TEST METER
MAIN VALVE
AIR-TIGHT PUMP

Figure 9-6. Method 13 total fluorides sampling train

standard with a certified value of 3.84 per cent fluoride was measured to have an average value of 3.88 per cent fluoride based on 5 determinations. The accuracy of fluoride electrode measured has been reported to be in the range of 1 to 5 per cent in the concentration range of 0.04 to 80 mg/l.

9.4 METALS

Aluminum, calcium, magnesium, sodium, and zinc emission rates can be measured using sampling and analysis techniques similar to those specified in Method 104 - Reference Method for Determination of Beryllium Emissions from Stationary Sources.[5] The sample collection system and technique are basically the same as described in Method 5 for particulate in that a representative sample is collected from the duct gas by isokinetically sampling at the centroids of equal areas of the duct cross section. The sample temperature is maintained to prevent condensation. If this temperature is below 367°K (200°F), the sample passes through a membrane filter in an oven. After exiting the filter, the sample stream flows immediately through two impingers containing distilled water, a dry impinger and a drying tube. If the sample temperature exceeds 367°K (200°F), the sample stream flows from the probe through an impinger with distilled water, then through the filter and remaining impingers. The sample then flows through a pump, dry gas meter and calibrated orifice (Figure 9-7).

Upon completion of sampling, the filter and loose particulate are placed in a sample container and the contents of the impingers plus probe and glassware washings are poured into a second container. The samples are digested in an acid solution, dissolved in hydrochloric acid and analyzed by atomic absorption spectrophotometry at the wavelength specific to the metal of interest. The concentration of the metal of interest is multiplied by the volume of hydrochloric acid and the interferences from the acetone and water are subtracted to obtain

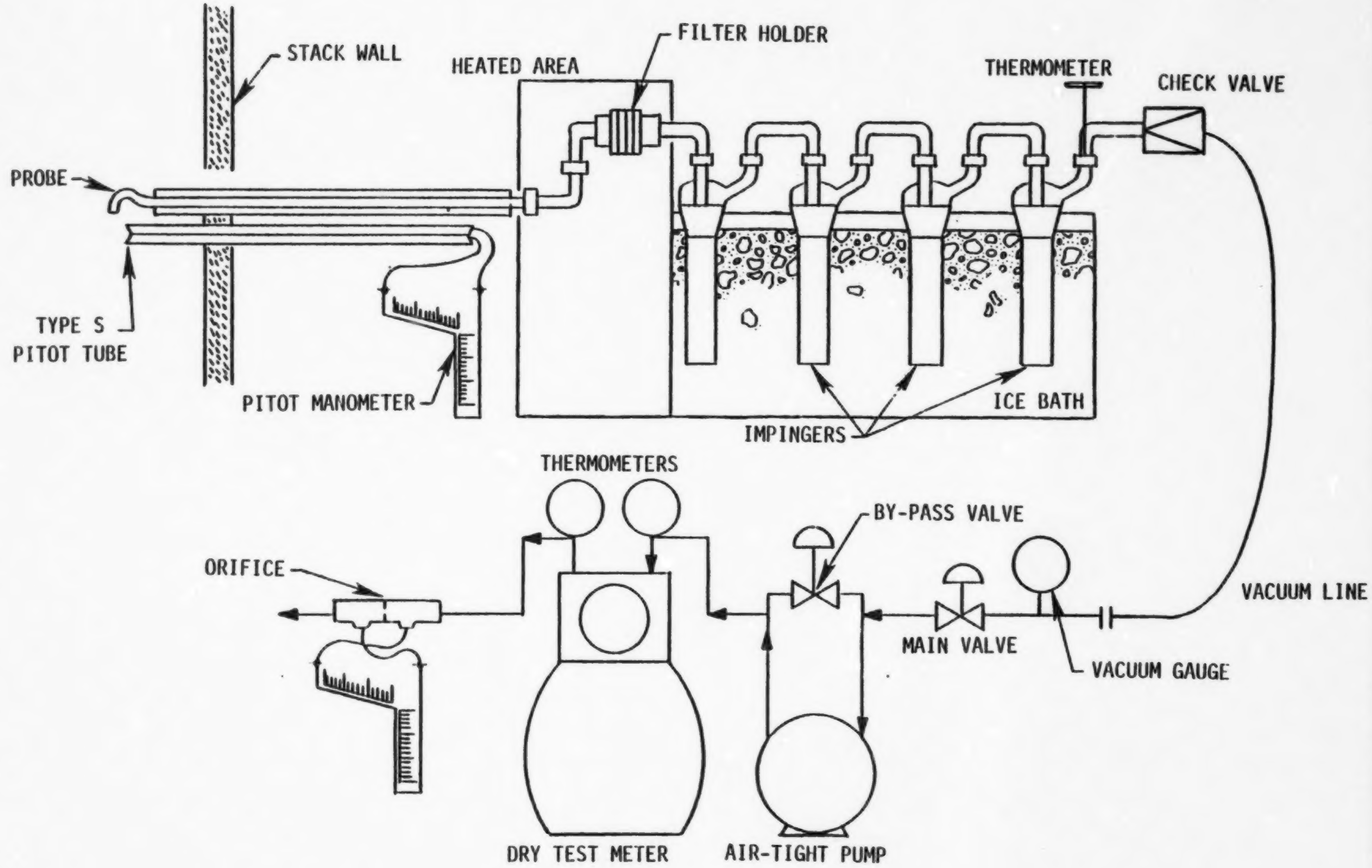

STACK WALL
FILTER HOLDER
HEATED AREA
THERMOMETER
CHECK VALVE
PROBE
TYPE S
PITOT TUBE
PITOT MANOMETER
ICE BATH
IMPINGERS
THERMOMETERS
BY-PASS VALVE
ORIFICE
VACUUM LINE
MAIN VALVE
VACUUM GAUGE
DRY TEST METER
AIR-TIGHT PUMP

Figure 9-7. Metals sampling train

the weight of metal collected. To obtain the emission rate, this weight is divided by the sample volume corrected to standard conditions and multiplied by the volumetric flow rate in the duct corrected to standard conditions.

9.5 TOTAL HYDROCARBONS

Total hydrocarbon (THC) emission rates can be measured using Intersociety Committee Method 108 "Tentative Method for the Continuous Analysis of Total Hydrocarbons in the Atmosphere"[6] (Flame Ionization Method) modified to prevent condensation in the sampling line between the sampling points and the detector. A sample is extracted from the midpoint of the duct after ascertaining that the concentration is uniform by making a preliminary traverse of the duct with the sampling probe. The extracted sample passes through a heat traced Teflon-lined sampling line to maintain sample integrity. The sample line is connected to a total hydrocarbon analyzer capable of operating in the required THC concentration range. The analyzer is fitted with heat traced lines to the flame ionization detector (Figure 9-8). The analyzer is zeroed and calibrated with a known concentration of methane in nitrogen both preceeding and following monitoring of the duct concentration. The velocity is measured concurrently with THC monitoring using a pitot tube in accordance with Method 2 - Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube).[1] The emission rate is calculated from the THC concentration measured as methane multiplied by the volumetric flow rate in the duct.

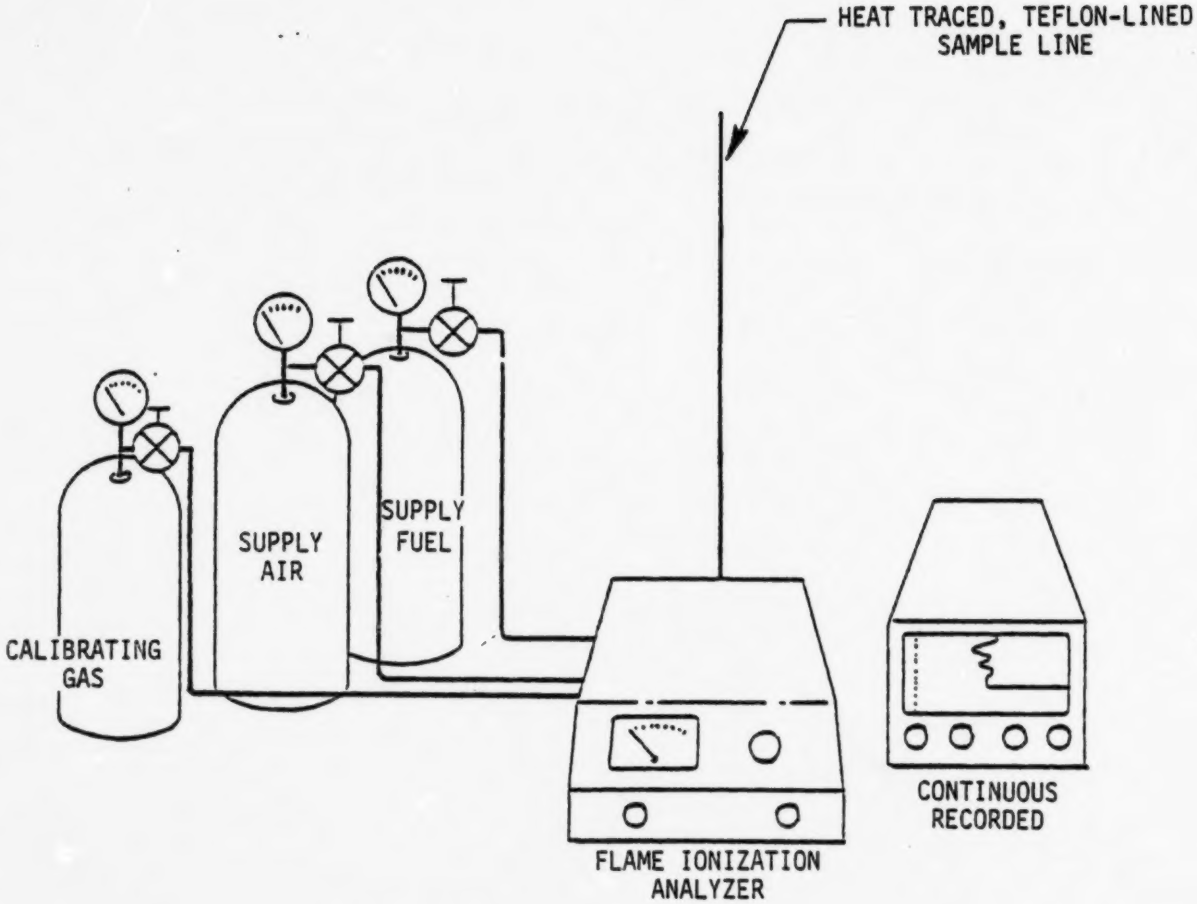

HEAT TRACED, TEFLON-LINED SAMPLE LINE
SUPPLY FUEL
SUPPLY AIR
CALIBRATING GAS
FLAME IONIZATION ANALYZER
CONTINUOUS RECORDED

Figure 9-8. Total hydrocarbon sampling system

9.6 CHLORIDES

Chloride (HCl)and Cl_2) emission rates can be measured by using a sampling technique similar to that described in Method 6 - Determination of Sulfur Dioxide Emissions from Stationary Sources[1] and the Argentometric Method[7] for analysis. A sample of the duct gas is extracted at a rate proportional to the duct gas velocity. The duct gas passes through a plug of glass wool to remove any particulate, and then the sample flows through the probe to four midget bubblers in an ice bath. The first two bubblers contain 40 ml of 0.1 N NaOH for HCl and alkaline arsenite for Cl_2, the third if dry and the forth contains silica gel to dry the sample stream. The sample stream then passes through a pump, flow meter and a dry gas meter (Figure 9-9).

Upon completion of sampling, the contents of the impingers plus the rinse water are measured with a graduated cylinder and poured into a sample container. To anlayze for hydrochloric acid or Cl_2, the Argentometric Method is used to determine the chloride content. The principle of this analysis method is to use potassium chromate to indicate the end point of a silver nitrate titration. To obtain the emission rate, the calculated weight of HCl and Cl_2 is divided by the sample volume corrected to standard conditions and multiplied by the volumetric flow rate in the duct.

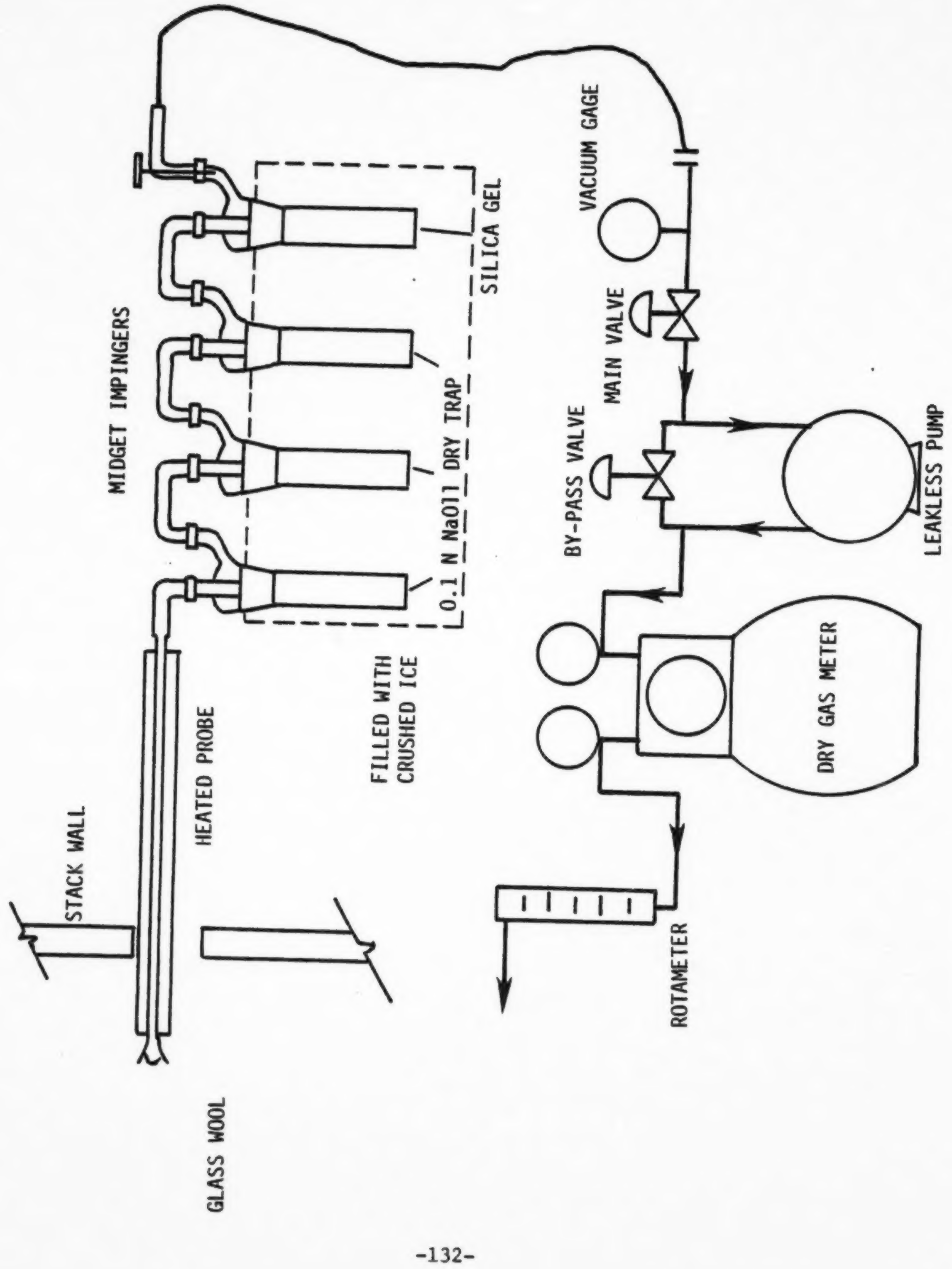

GLASS WOOL
STACK WALL
HEATED PROBE
FILLED WITH
CRUSHED ICE
MIDGET IMPINGERS
0.1 N NaOH
DRY TRAP
SILICA GEL
VACUUM GAGE
MAIN VALVE
BY-PASS VALVE
LEAKLESS PUMP
DRY GAS METER
ROTAMETER

Figure 9-9. Hydrogen chloride sampling train

REFERENCES FOR SECTION 9

1. Standards of Performance of New Stationary Sources. Appendix A - Reference Methods. Federal Register. Vol. 42. No. 160. August 18, 1977.

2. Ibid. Vol. 43, No. 37. February 23, 1978.

3. Ibid. 39 FR 20790. June 14, 1974.

4. Ibid. 41 FR 52299. November 29, 1976.

5. National Emission Standards for Hazardous Air Pollutants. Appendix B - Test Methods. Federal Register. 39 FR 15396. May 3, 1974.

6. Methods of Air Sampling and Analysis. Intersociety Committee, American Public Health Association, Washington, DC, 1972.

7. Standard Methods for the Examination of Water and Wastewater. 13th Edition. American Public Health Association, New York, 1971.

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10. INDIVIDUAL PLANT EXAMPLES

Plant visits were made to two secondary aluminum manufacturing plants to gain first-hand information on the types of processes and controls in use in the industry. The two plants visited were the Vulcan Materials Company in Sandusky, Ohio and the Allied Metal Company in Chicago, Illinois. These two were selected due to their having potential best systems of emission control. The two plants also provided a contrast as to type of demagging, type of emission control, size and layout. The results of the visits are discussed in the following sections. More detailed trip reports are included in Appendix A.

10.1 VULCAN MATERIALS COMPANY

The plant visit to the Vulcan Materials Company was made on June 27, 1978. Jack Eagan, Manager of Environmental Control, and John Hrovatich, Plant Manager, discussed their plant's operation and conducted a tour of the facilities. The steps they use to process their incoming scrap and produce ingots are described in the following paragraphs:

- Incoming scrap - The scrap percentage breakdown at their plant is the following:

Chips, punchings, leftovers	- 31%
Painted siding	- 6%
Can stock	- 8%
Old cast (pistons, transmissions)	- 3%
Sheet	- 3%
Borings	- 12%
Dealer pig (primary pig)	- 16%
Other	- 21%

- Fragmentizing metallic scrap - Approximately 35 percent of their incoming scrap is fragmentized via a hammermill crusher down to fist-sized chunks. This scrap typically includes sidings, chips, borings, cans, turnings, sheet and casts. Large masses are hand picked rather than crushed as they could damage the machine. The emissions from this step are large particles such as dust, chips, and dirt. Any small, suspendible particulate is controlled via a baghouse.

- Drying metallic scrap - Approximately 40-50 percent of their scrap is put through a rotary drum chip dryer in order to burn off the oil and water and incinerate paints and plastics. The dryer is gas-fired and operates at 533-811°K (500-1000°F) depending on the material to be incinerated. The type of scrap is contaminated borings and turnings. The emissions from this step are smoke, hydrocarbons, and vaporized oils. These are controlled with a gas-fired afterburner that operates at around 1089°K (1500°F) and has a residence time of 1.5-2.0 seconds. A baghouse is used over the transfer points on the conveyors to control any dust generated.

- Sweat processing metallic scrap - Approximately 5-10 percent of their scrap is high in iron and goes through a dry hearth furnace in order to melt off the aluminum from the iron. The furnace operates at 1367°K (2000°F) and the melting point of aluminum is 922°K (1200°F). About 10-20 percent of the aluminum is lost due to burn-off. Most of the organics are burned-off, but there are some organic and inorganic emissions. These are controlled by an afterburner.

- Wet mechanical separation of metal from skimmings - The skimmings and drosses from the furnace contain 15-20 percent aluminum and so they are reprocessed in order to recover some percentage. A rotary drum ball mill is used in which the salts are washed out while the aluminum stays coarse and is left on a screen. There are no air emissions, but a water pollution problem develops which is why many industries do not use this process.

- Sweat processing residual scrap - Vulcan does not try to remove the aluminum from the residuals since they feel too much is lost if it is sweated. They put the concentrates back into the furnace.

- Magnetic separation - A roll magnet is used at the end of the crusher and dryer in order to separate the irony scrap from the treated and untreated scrap aluminum.

- Melting and alloying - Vulcan has six reverberatory furnaces of which five operate at one time in a cyclic arrangement. The other furnace is down for cleaning. All types of scrap are charged in the furnace. A typical flux is used ($NaCl$, KCl, cryolite). Very little emissions arise from the charging and fluxing since most of the organics burn off in the chamber. There is a controlled rate of feed with dirty scrap charged at a low rate so that there is more time for contaminant burn-off. Demagging is accomplished via gaseous chlorine injection under a submerged dome. The dome contains the fumes ($MgCl$, for example) and passes them to a scrubber which is claimed to be extremely efficient. The water being discharged is sent to public treating plants.

- Pouring - Their product line includes casts, harder alloy aluminums used in casting, and copper and silica alloys.

Some additional information that was obtained is listed as follows:

- They employ about 110 people.

- Their operation is quite spread out with many separate buildings.

- Many of their operations are done by hand (such as fluxing and skimming) since they are essentially an art and no procedure can really be written down. Whether you recover aluminum or burn it off depends quite a bit on the operator.

- The cost of the scrap is typically 80-90 percent of the selling cost. The rest is made up of the fuel costs, operating costs, etc. The fuel cost recently went from 1/2 to 2¢ per pound which, in turn, affects the pollution control equipment since they need fuel to operate.

- Scrap supply is short sometimes and there have been cases where the cost of the scrap has been greater than the market value of the product.

- There is a severe problem with the wastewater. Although the plant is not now out of compliance, compliance with the 1977 Clean Water Act might prove difficult. This Act controls some 60 toxic materials going to a public wastewater treatment plant. Controls will have to be installed to remove the organics (such as the aluminum hydroxides) or else everything will have to be evaporated. There will then be a solid waste problem since the dried material will contain salts and cannot be used for landfill. Economics is a major factor.

10.2 ALLIED METAL COMPANY

The plant visit to the Allied Metal Company was made on June 28, 1978. Marvin Fink, Vice President, discussed the operations of the plant and then led a tour of the facility. The steps they use to process their scrap and produce ingots are described in the following paragraphs:

- Incoming scrap - Allied's scrap is varied and consists of cast and sheet scrap, clippings, borings, turnings, cans, remelt sows, etc. The scrap is hand-sorted at first and then the metallics and non-metallics are separated via a magnetic separator. No crusher is used.
- Drying metallic scrap - Any contaminated scrap (about 10 percent of their incoming scrap) such as borings and turnings which contain grease and oil, are sent to a dryer where the impurities are burned off. They use a rotary drum type dryer which is started on natural gas and then runs on the combustibles present in the contaminated scrap. They use an afterburner for emission control with a hood over the loading area.
- Sweat processing metallic scrap - Approximately 20 percent of their scrap goes to a sweat furnace where the aluminum is melted away from the iron. The furnace runs on natural gas (summer) or oil (winter). The emissions from this process are controlled by the same baghouse that controls the reverbatory furnace emissions (this will be discussed further in the paragraph on the reverbatory furnace).
- Wet/dry mechanical separation - Allied does not conduct any mechanical separation of the metal from the skimmings/drosses and the residues are not reprocessed. These items are disposed of by a commercial carrier as solid waste.
- Melting and alloying - Allied uses two reverberatory furnaces for their melting and alloying. The input is about 10 percent dried scrap, 20 percent sows from the sweater and 70 percent direct. The furnaces run on natural gas (summer) and oil (winter). The charging of the scrap takes approximately 16 hours of a 24 hour cycle. The flux used is the standard industry flux (NaCl, KCl, cryolite). The emissions are controlled by a baghouse system designed and installed by Teller Environmental Systems, Inc. The bags are coated

with nepheline syenite which absorbs chlorides and fluorides. While at the plant, an extremely oily bundle of borings was charged in order to show the effectiveness of the capture system and the baghouse. The scrap would normally be dried first to decontaminate it, but this was not done to prove a point. The charged scrap produced a thick black smoke that was effectively captured by the hood (very little smoke escaped). An examination of the baghouse exhaust during this charge revealed no visible emissions. The baghouse utilizes a quencher between the furnace exhaust and the baghouse inlet. This water quencher operates automatically whenever the exhaust gas temperature reaches a certain level, thus preventing bag burn-out. The water used for quenching is evaporated so that there is no water pollution problem. The baghouse uses roughly 454 kg (1000 lbs) of coating material per week and the cleaning time is once per week (shaker mechanism). The solid waste is taken away commercially along with the other solid wastes. The sweat furnace and furnace flues are also connected to this baghouse system. The cost of installation of the baghouse was approximately $500,000.

- Demagging - Demagging is accomplished using aluminum fluoride (AlF_3). This is added in 45.4 kg (100 lb) sacks at the charging well once per cycle (about 1.5 hours are spent demagging per cycle). Approximately 454 kg (1000 lbs) of AlF_3 is applied per cycle at the ratio of about 1.6 kg (3.5 lbs) of AlF_3 to every 0.45 kg (1 lb) of magnesium removed.

- Pouring - Allied's end products are the 319 and 380 alloys poured as ingots. These are about 85 percent aluminum, 8-9 percent silica, 4 percent copper, and some iron and zinc.

Some additional information that was obtained is listed as follows:

- They employ approximately 60 people.

- Their entire operation is contained under one roof which is approximately 21.3 meters (70 feet) high. This high roof permits excellent air flow to the hoods.

- Air is introduced to the melt during charging to promote mixing.

- The baghouse was designed for three reverberatory furnaces plus the sweater. They only have two furnaces so that there is room for expansion.

- There is a solid waste disposal problem. They have no water problem, but their wastes contain fluorides which are most likely dumped and can leach back into the soil and water system.

11. RECOMMENDATIONS FOR STANDARDS

The three main sources of air pollution from the secondary aluminum process are:

- Chip dryer (particulate, hydrocarbons, carbon monoxide)
- Sweat furnace (particulate, hydrocarbons, carbon monoxide)
- Reverberatory furnace (particulate, hydrocarbons, carbon monoxide, chlorine gas, gaseous fluorides).

State and local regulations currently exist governing particulate emissions. The overall particulate emissions from the secondary aluminum industry, assuming that these regulations are enforced, is estimated to be 1,933,000 kg (2130 tons). By applying best available control technology (BACT), these emissions can be reduced 47 percent to 914,300 kg (1010 tons). These quantities, however, are small compared to the estimated carbonaceous chlorine and gaseous fluoride emissions. Standards could be set, but the impact would not be very severe.

The demagging process results in the most significant emissions of any secondary aluminum process. Using Model IV, chlorine emissions are estimated to be 21,171,000 kg (23,340 tons) and gaseous fluoride emissions are estimated to be 3,094,200 kg (3382 tons), assuming no controls. There are, at present, very few state or local regulations governing chlorine and gaseous fluoride air emissions. Control technology does exist, however, which could reduce these emissions by greater than 99 percent. Emission standards should be set for the chlorine and gaseous fluoride emissions that result from the demagging operation in the secondary aluminum process.

Compounds of fluorine and chlorine might also be emitted from dryers, sweat furnaces, and charging of reverberatory furnaces when scrap associated with compounds such as Teflon and polyvinylchloride are processed. However, such emissions would be of relatively small quantity and might be controlled by segregating the affected scrap and charging it to a reverberatory furnace equipped with a coated baghouse. or a scrubber that operates during charging.

It should also be noted that hydrogen chloride (HCl) is formed by the hydrolysis of particulate $AlCl_3$, and by Cl_2 reacting with H_2 in the melt during Cl_2 demagging. Thus, amounts of HCl might be present in uncontrolled chlorination emissons. Control of HCl might be omitted from the standards, however, because control of particulate and Cl_2 by a scrubber, or a scrubber and coated baghouse, would also control HCl.

The carbonaceous emissions (HC and CO) can also be significant and should be examined in terms of possible regulation. At present, there are no regulations for these parameters. Control technology exists that can reduce these emissions by approximately 99 percent.

Any standards that are set would be based on best available control technology (BACT). This was shown to be the coated baghouse and/or scrubber with submerged dome capture system for the reverberatory furnace and the afterburner/baghouse combination for the dryers and sweat furnaces (where it is not possible to tie into a coated baghouse system).

Table 11-1 summarizes the affected facilities, the pollutants associated with their operation, and the best control systems available reduce these emissions.

Table 11-1. THE FACILITIES, POLLUTANTS AND CONTROL SYSTEMS FOR POSSIBLE STANDARDS FOR THE SECONDARY ALUMINUM INDUSTRY

Affected Facility	Pollutants	Control System
Dryer	Particulate Condensible HC Gaseous HC CO	Afterburner/baghouse
Sweat Furnace	Same as dryer	Afterburner/baghouse or coated baghouse
Reverberatory furnace with AlF_3 demagging	Particulate Condensible HC Gaseous HC CO Gaseous fluorides	Coated baghouse
Reverberatory furnace with Cl_2 demagging	Particulate Condensible HC Gaseous HC CO Cl_2 HCl	Scrubber with submerged dome capture and/or coated baghouse

However, before any meaningful, realistic standards can be promulgated, there are three major areas that require further examination:

- Emission data
- Water/solid waste disposal
- Economics

More emission data must be obtained before any kind of meaningful standards can be set. Data is needed on both emission factors and control device efficiencies. The tradeoff between solving the air pollution problem but creating either a solid waste disposal problem (associated with baghouses) or a water waste disposal problem (associated with scrubbers) must be considered. Finally, the economics of the industry must be examined. The secondary aluminum industry is currently in an unfavorable economic position which could severely hinder the purchase and installation of control devices.